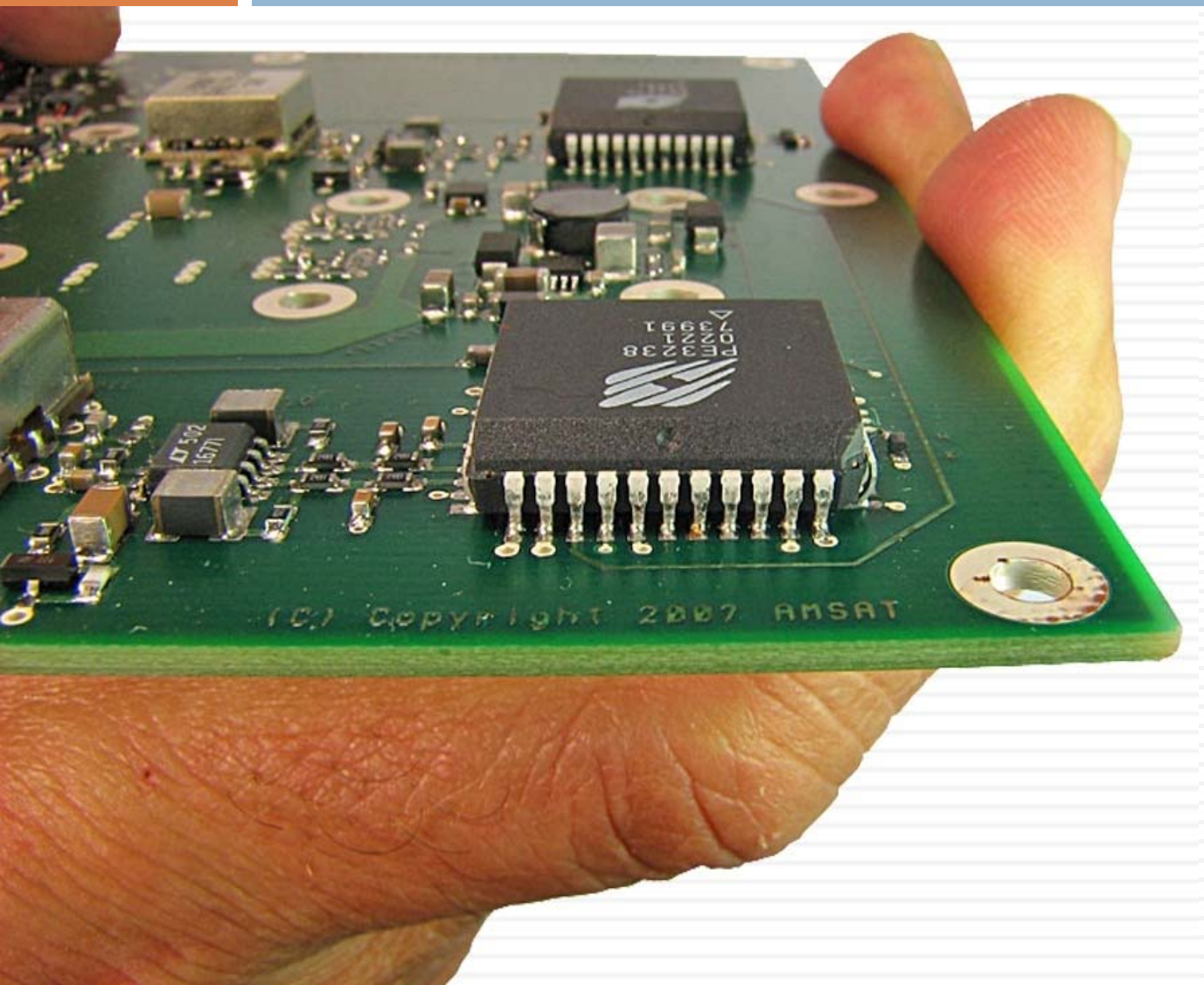
70 cm Receiver



70 cm Receiver

Progress Report and Lessons Learned

Presented by

Juan Rivera – WA6HTP

70 cm Receiver

- Introduction
- Preparations
- Payload Elements
- Receiver Construction
- Reflow Soldering
- Testing
- Troubleshooting
- Rework
- What's Next?

The Team

- RF and PCB Design
  - John B. Stephensen KD6OZH
- Project OSCAR
  - Dave Black W6MOF
  - Don Ferguson KD6IRE
  - Dave Hartzell N0TGD
  - Bill Ress N6GHZ
  - Juan Rivera WA6HTP
  - Greg Samsonoff KI6IKG
  - Dave Smith W6TE

It's Better to be Second!

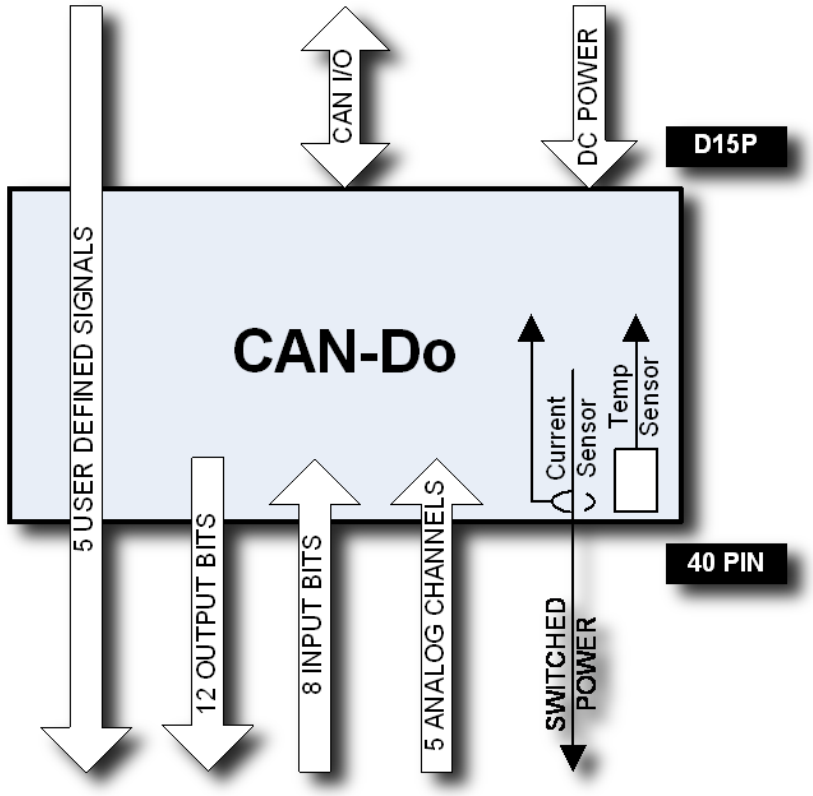
- First Eagle Payload to be Funded
- First Prototype Constructed
- First to Integrate with a CAN-Do Module
- First to be Installed in an Enclosure
- First Payload Extensively Tested

Payload Elements

- CAN-Do Module
- Receiver
- Enclosure

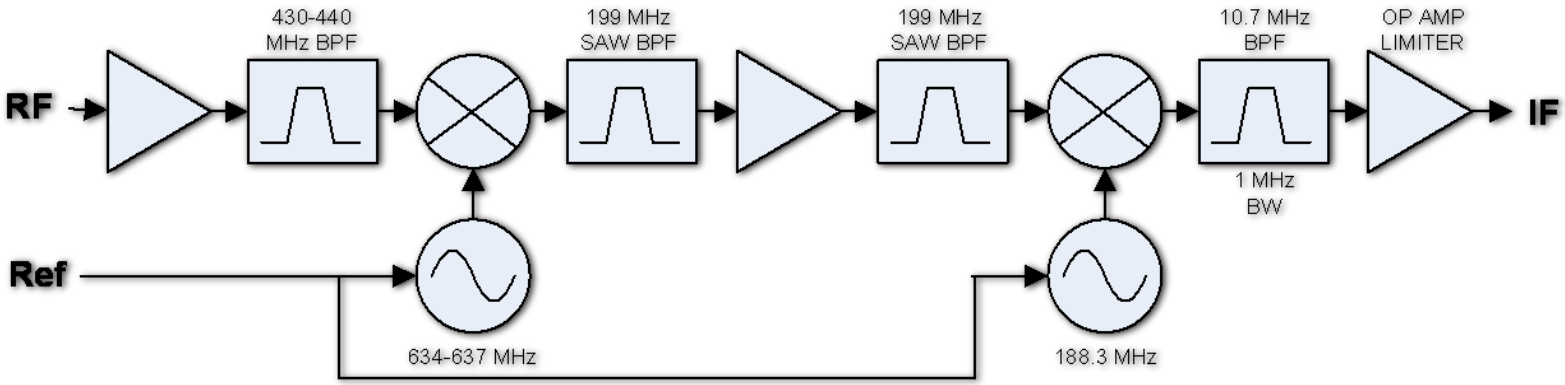
CAN-Do Module Functional Block

- CAN-Do Module
  - Power
  - Control
  - Telemetry
  - Measures Current and Temperature



Receiver Functional Block

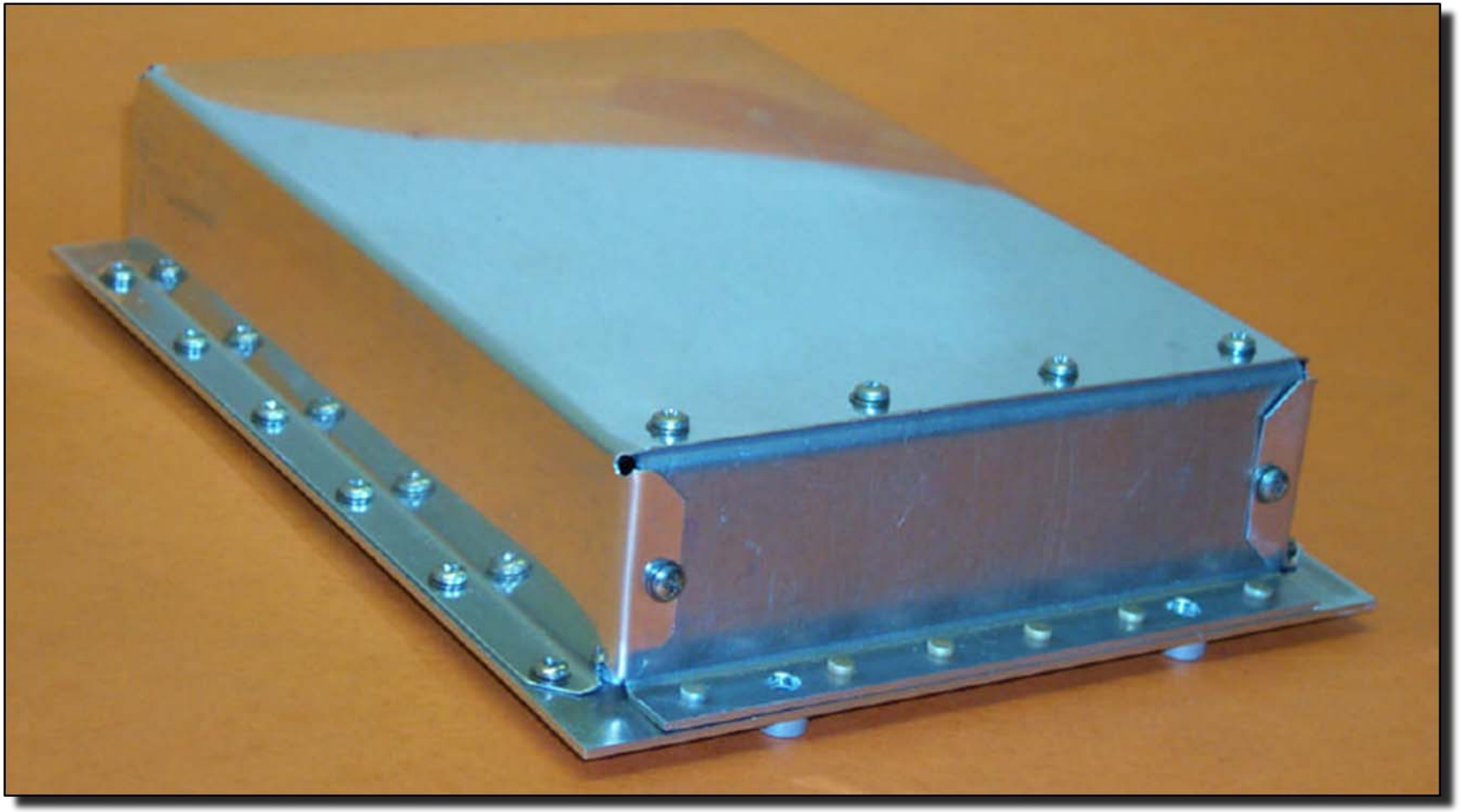
- Tunable Dual Conversion Superhetrodyne Block Down-Converter



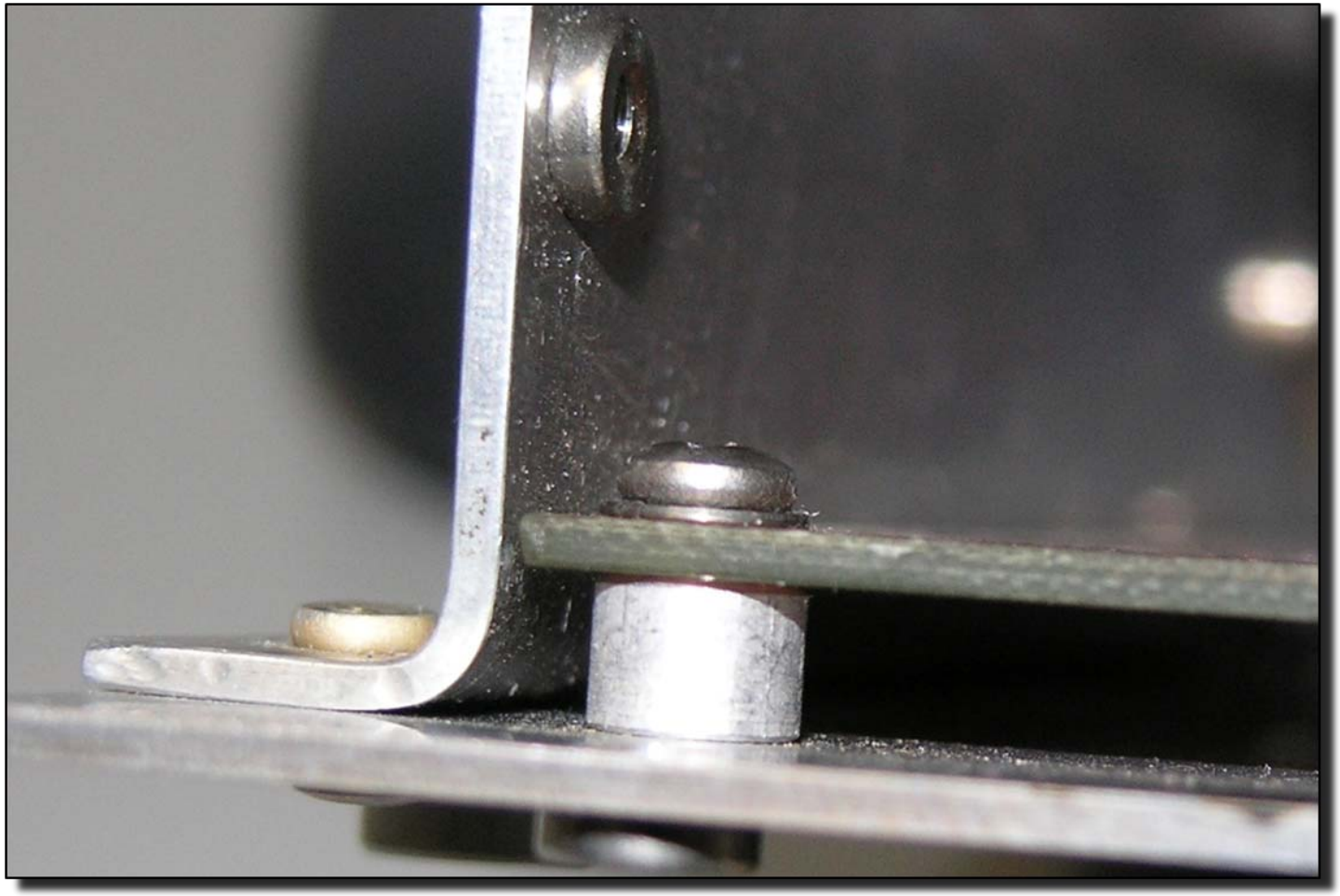
Enclosure Construction

- Aluminum Sheet Metal Construction
  - Baseplate
    - 10 Self-Clinching Standoffs
    - 3 Heat Sinks
    - 22 Self-Clinching 4-40 Nuts
  - Front Panel
    - CAN-Do Module Mount
    - All I/O Connectors
  - Cover

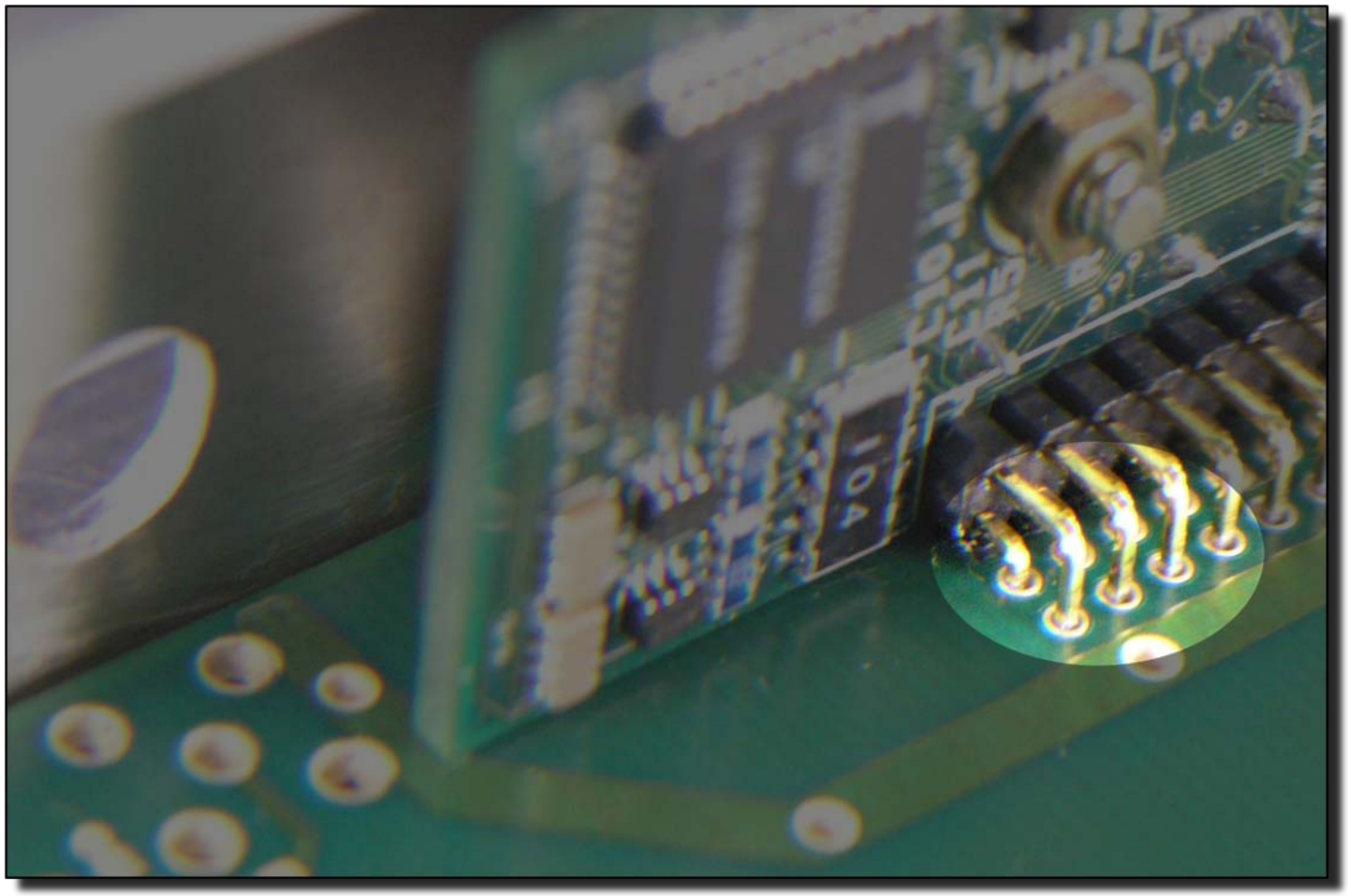
Enclosure



Front Panel / PCB Detail



CAN-Do 40-Pin Header

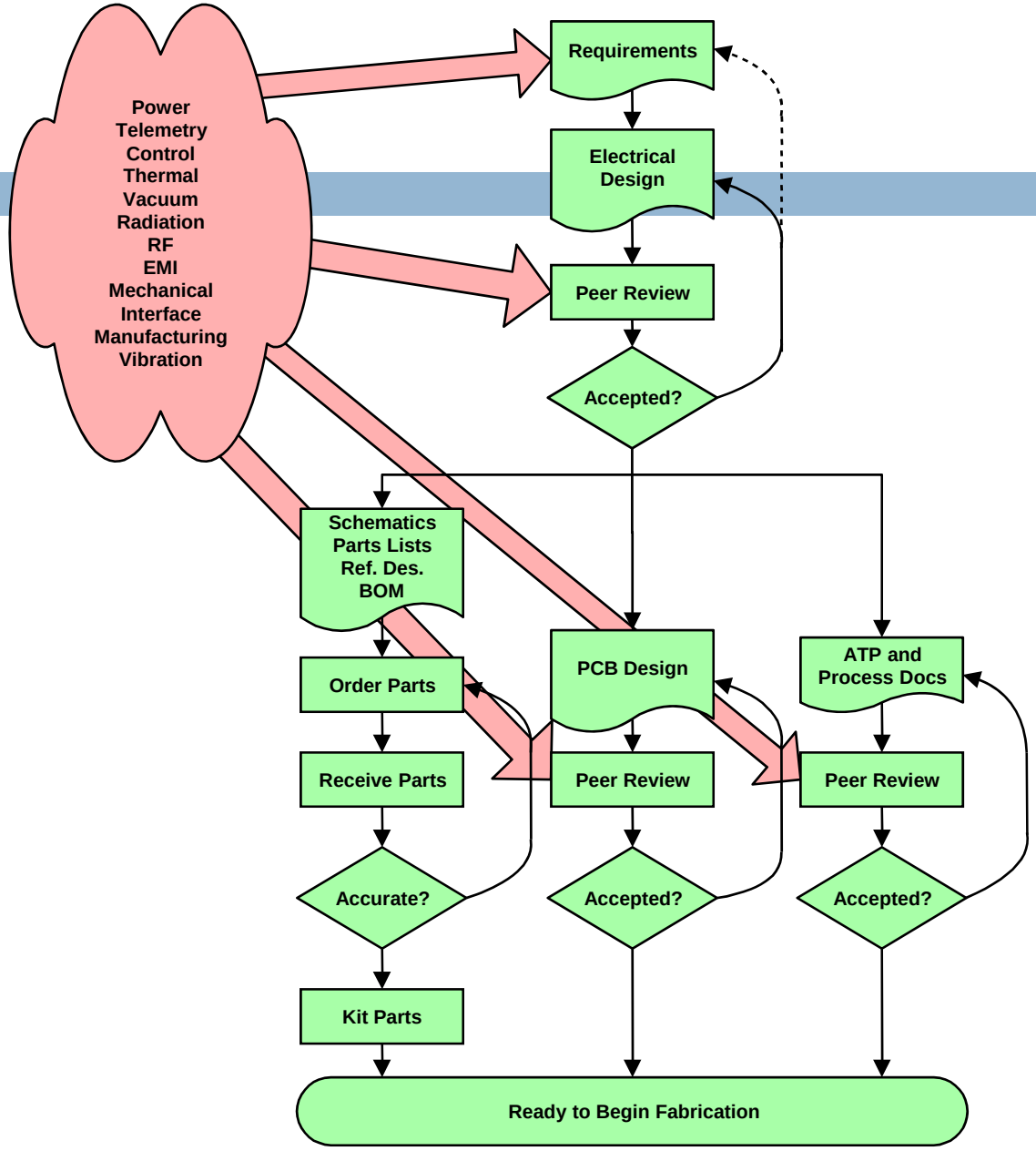


Preparations

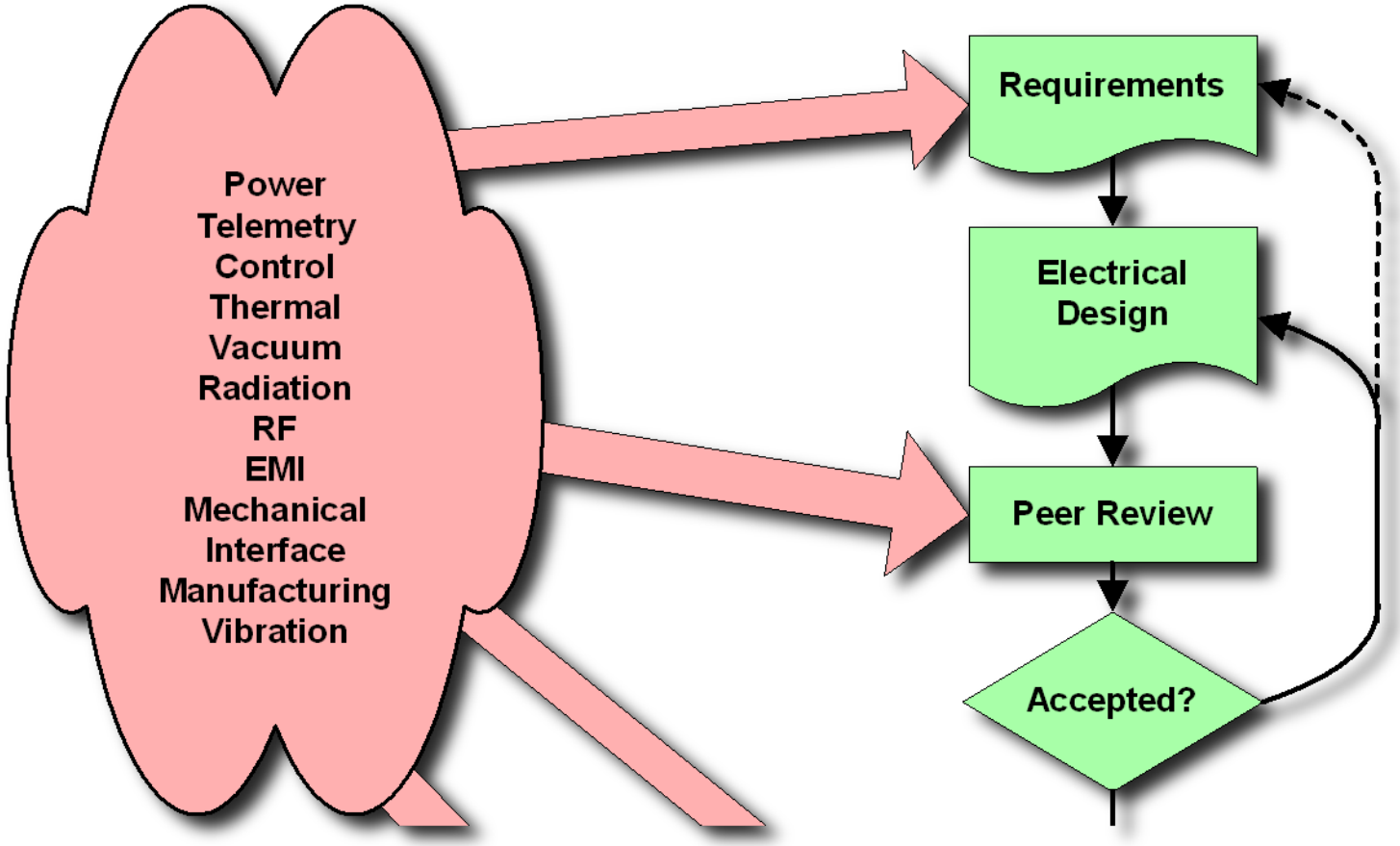
Proper Prior Planning Prevents Poor Performance !

Beginning the Project

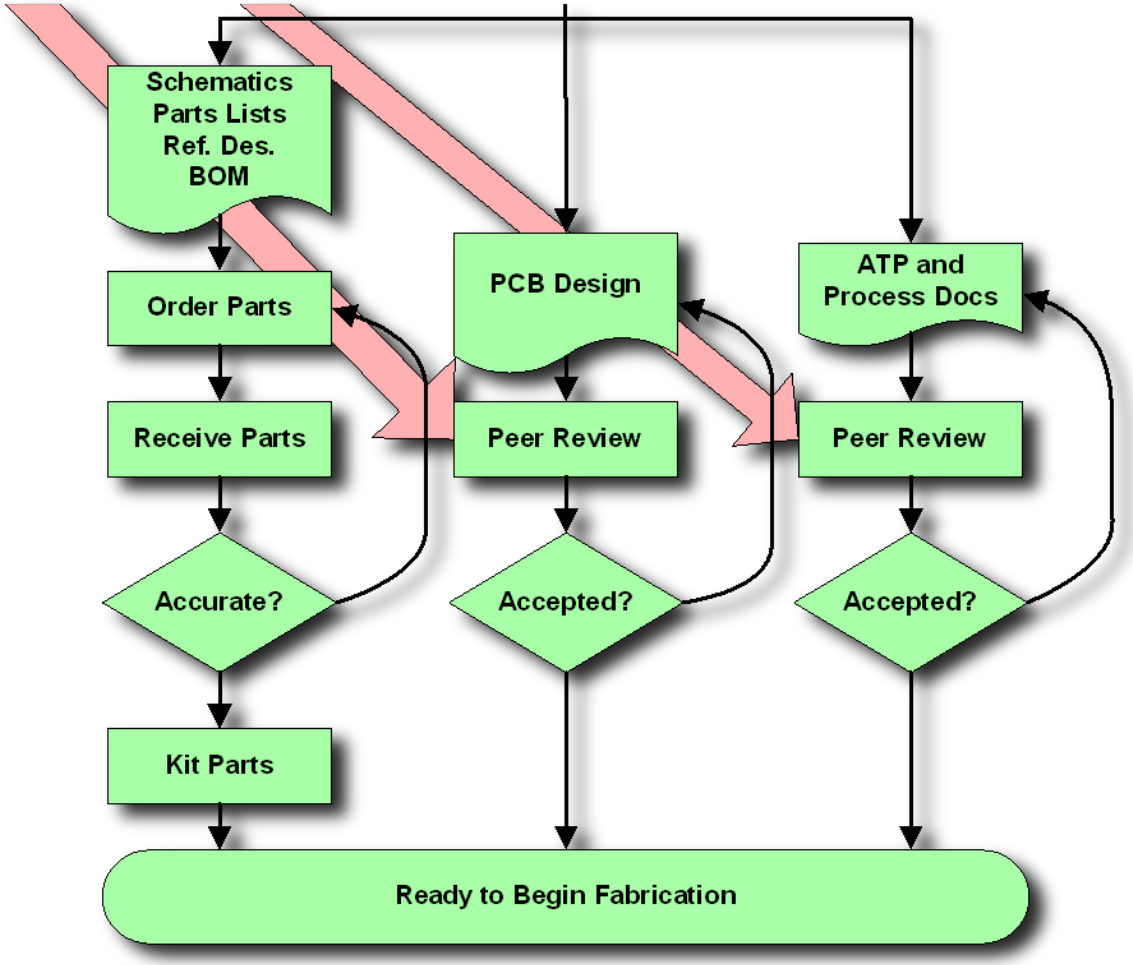
- Define Requirements
- Design Circuit and Layout PCB
- Create Parts List
- Create Bill of Materials
- Order Parts
- Create Construction Procedure
- Create Acceptance Test Procedure (ATP)
- Peer Review EVERYTHING!!


Power
Telemetry
Control
Thermal
Vacuum
Radiation
RF
EMI
Mechanical
Interface
Manufacturing
Vibration
Requirements
Electrical Design
Peer Review
Accepted?
Schematics
Parts Lists
Ref. Des.
BOM
Order Parts
Receive Parts
Accurate?
Kit Parts
PCB Design
Peer Review
Accepted?
ATP and Process Docs
Peer Review
Accepted?
Ready to Begin Fabrication

The Process


Power
Telemetry
Control
Thermal
Vacuum
Radiation
RF
EMI
Mechanical
Interface
Manufacturing
Vibration
Requirements
Electrical Design
Peer Review
Accepted?

The Process (Cont.)



Bill Of Materials

Microsoft Excel - Eagle_70_cm_Rx_BILL_OF_MATERIALS-1.xls

File Edit View Insert Format Tools Data Window Help Adobe PDF

A3 rev. 4/20/2007 1655 PDT - PROJECT OSCAR - W6TE

AMSAT- NA EAGLE PROJECT

U-BAND RECEIVER - BILL OF MATERIALS

rev. 4/20/2007 1655 PDT - PROJECT OSCAR - W6TE

LINE	QTY	PARTS LIST PART NUMBER	MANUFACTURER PART NUMBER	DESCRIPTION	REF	FOOT PRINT	SUPPLIER	SUPPLIER PART NUMBER	PRICE EACH	QTY	SPARE	ON HAND	TOTAL	ORDER	TOTAL	STOCK	ORDER DATE	ORDER NUMBER	RECEIVE DATE	MOISTURE SENSITIVITY LEVEL (MSL)
				SEMICONDUCTORS																
1	1	XN01211 XN01212 XN01213	PANASONIC XN01211 XN01212 XN01213	DUAL TRANSISTOR ARRAY NPN/NPN W/RES; Rbe=10K, Rbg=10K	U1	MINI5P	DIGIKEY	XN0121200LCT-ND	$ 0.35	4	1	5	10	10	$ 3.47	X	4/10/07 W6TE	19489839	RECEIVED	
2	1	SBB2089	SIRENZA SBB2089	0.05 - 0.5MHz InGaP HBT Active Bias Gain Block	U2	SOT-89	RFMW	SBB-2089	$ 2.87	4	1	0	7	3	$ 8.61	X	4/5/2007 W6TE	205654	RECEIVED	
														6	$ 17.22	X	4/9/07 W6TE	205673	RECEIVED	
														6	$ 17.22	X	4/19/07 w6te	205762	RECEIVED	
3	2	LT5512EUF	LINEAR TECHNOLOGIES LT5512EUF#PBF	IC, SM MIXER DOWNCONV ; Bandwidth:3000MHz; Temp, op. max:85(degree C); Temp, op. min:-40(degree C); Pins, No. of:16; Base number:5512; Gain, over bandwidth:2dB; Voltage, supply DC min:5.5V RoHS Compliant: Yes	U3, U8	QFN	LINEAR TECHNOLOGY	LT5512EUF#PBF	$ 5.27	8	1	2	7	7	$ 36.89	X	3/31/07 W6TE	250-WEB-78444	RECEIVED	
4	2	PE3236 PE3238 PE9601	PEREGRINE PE3238-21	PLL, 2 GHz, CMOS Sol	U4, U9	PLCC	RICHARDSON ELECTRONICS	PE3238-21	$ 24.86	8	1	0	9	3	$ 74.58	X	4/5/07 W6TE	4265304	RECEIVED	
														6	$ 149.16	X	4/10/07 W6TE	4267297	RECEIVED	3
5	2	LT1677IS8	LINEAR TECHNOLOGIES LT1677IS8	Op. amp., VFB, 4nV/Hz noise	U5, U10	SOIC	LINEAR TECHNOLOGY	LT1677IS8	$ 2.80	8	1	2	7	7	$ 19.60	X	3/31/07 W6TE	250-WEB-78444	RECEIVED	
																	4/5/2007			

Parts in ESD Trays

Documentation

- Documentation
  - Requirements
  - Schematics
  - Parts List
  - Bill of Materials
  - Acceptance Test Procedure
  - PCB Layout Details
  - Construction Procedure
  - Tuning Matrix
  - Gain Trimming Procedure
  - Moisture Sensitivity Level Data
  - ESD Sensitivity Level Data
  - Maximum Solder Temperature

Construction Procedure Detail

Project Oscar – AMSAT/Eagle 70 cm Telecommand Receiver

Work Instructions

Shop Order No Part No

7 – Manual PCB Cleaning Process ____ ____ ____

Operation Description Detail:

NOTE: If the boards have been stored in hermetically sealed bags since manufacture then steps 7 and 8 may be skipped.

7.1 – Thoroughly rinse the PCB with running deionized water.

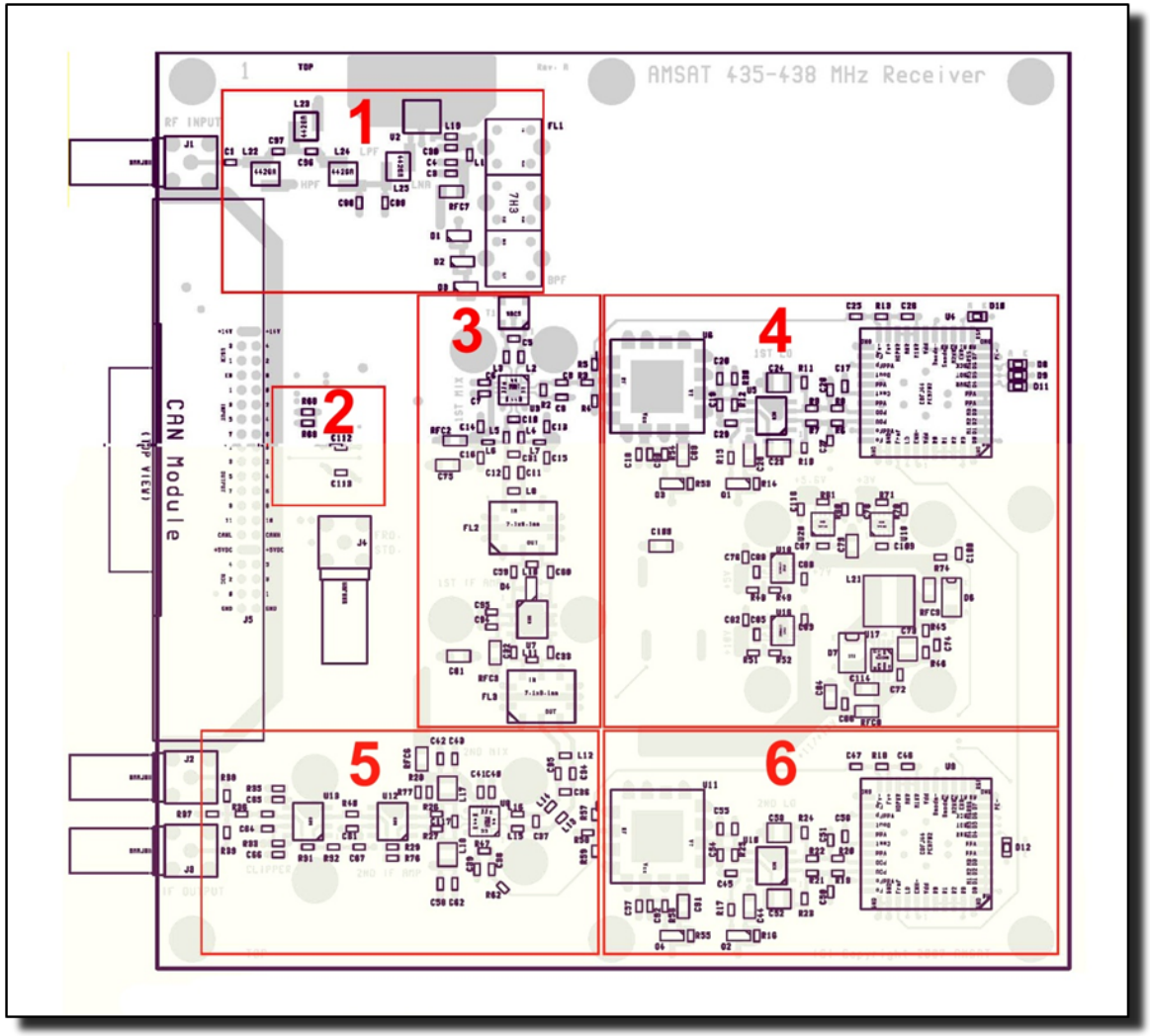
7.2 – Make up a solution of one tablespoon Detergent 8 dissolved in one quart of deionized water.

7.3 – Thoroughly scrub the PCB with a soft Tampico brush using the Detergent 8 solution until all visible contaminants have been removed.

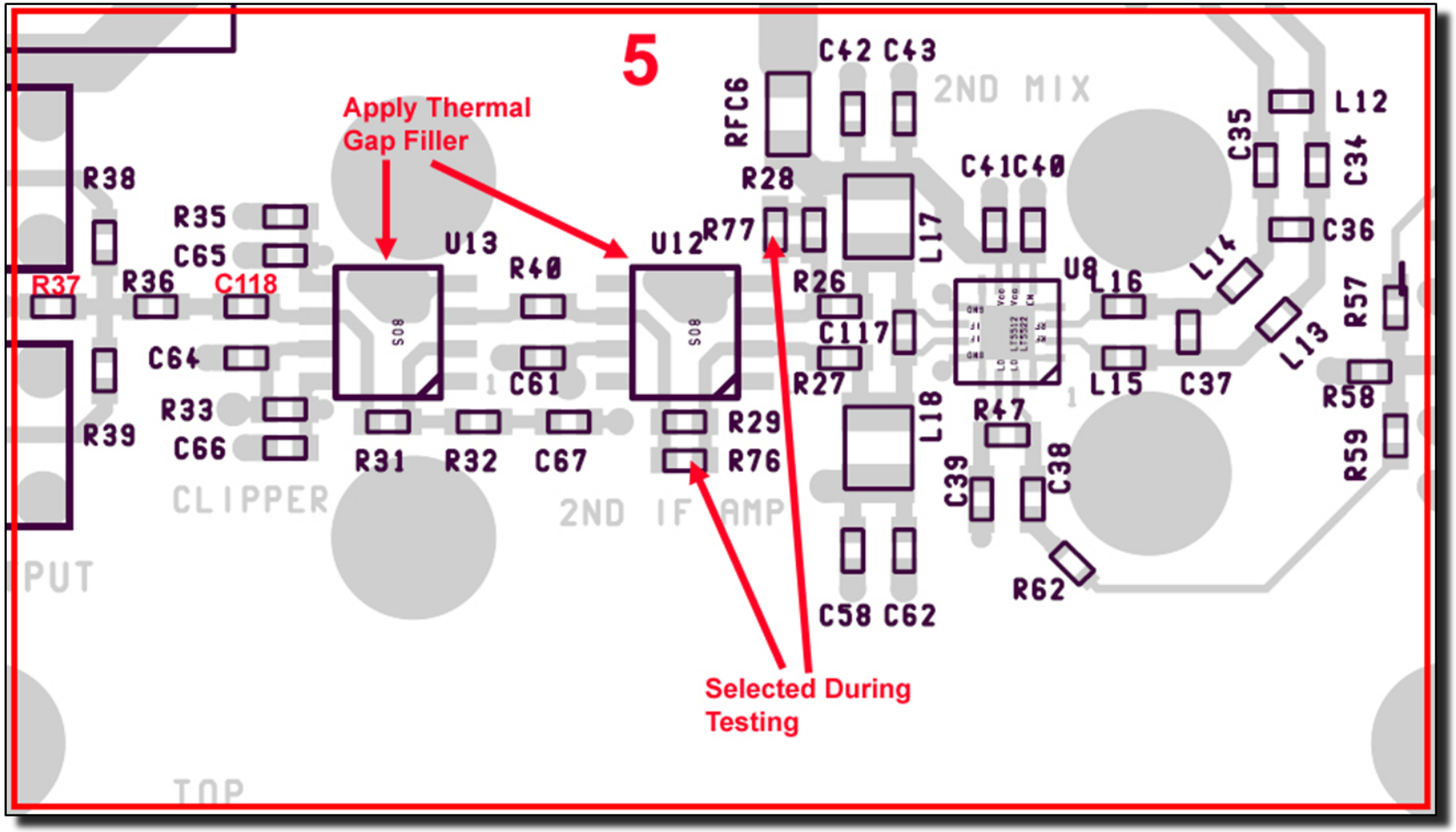
7.4 – Rinse PCB in deionized water; check for water-break indicating residual greasy surface. Repeat process until board is grease-free (no water breaks.)

7.5 – Do not reuse detergent or deionized water. Discard after use.

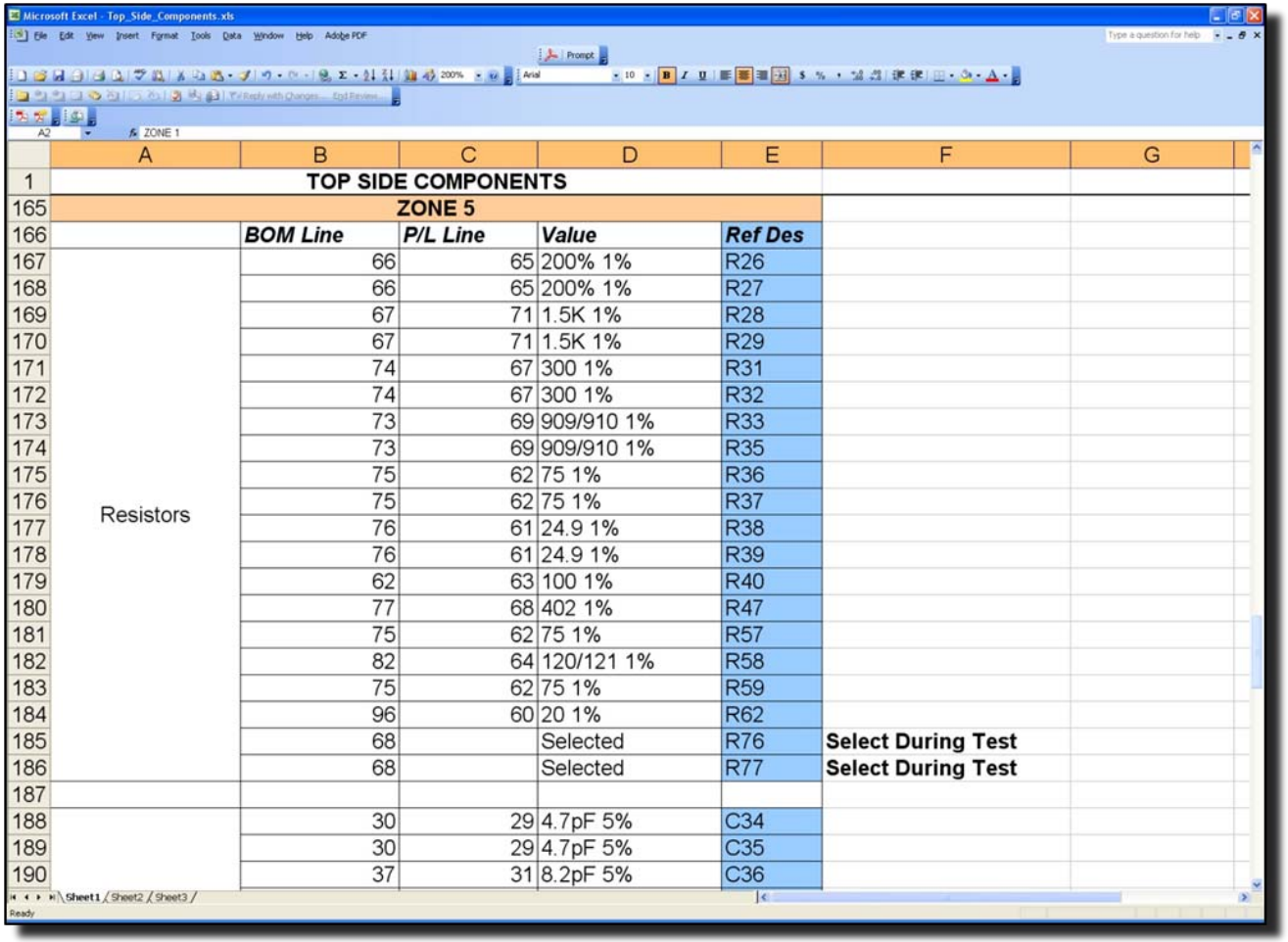
Construction Procedure Detail



Construction Procedure Detail



Construction Procedure Detail



	A	B	C	D	E	F	G
1	TOP SIDE COMPONENTS						
165	ZONE 5						
166		***BOM Line***	***P/L Line***	***Value***	***Ref Des***		
167		66	65	200% 1%	R26		
168		66	65	200% 1%	R27		
169		67	71	1.5K 1%	R28		
170		67	71	1.5K 1%	R29		
171		74	67	300 1%	R31		
172		74	67	300 1%	R32		
173		73	69	909/910 1%	R33		
174		73	69	909/910 1%	R35		
175		75	62	75 1%	R36		
176		75	62	75 1%	R37		
177	Resistors	76	61	24.9 1%	R38		
178		76	61	24.9 1%	R39		
179		62	63	100 1%	R40		
180		77	68	402 1%	R47		
181		75	62	75 1%	R57		
182		82	64	120/121 1%	R58		
183		75	62	75 1%	R59		
184		96	60	20 1%	R62		
185		68		Selected	R76	**Select During Test**	
186		68		Selected	R77	**Select During Test**	
187							
188		30	29	4.7pF 5%	C34		
189		30	29	4.7pF 5%	C35		
190		37	31	8.2pF 5%	C36		

Acceptance Test Procedure

Application Revisions			
Letter	Description of Change	Date	by
—	Initial Release	3/17/07	J. Rivera
a	Revised noise figure and gain test	4/7/07	G. Samsonoff
b	Switching Power Supply Noise Test	4/20/07	J. Rivera
c	Updated Can-do Section	4/28/07	D. Ferguson

Acceptance Test Procedure

		Project OSCAR Build Team			
Originator: J. Rivera – WA6HTP	Date 1/17/07	AMSAT - Project Eagle 70 cm Telecommand Receiver			
Checked by: R. Hambly	Date 2/6/07				
Approval: J. Sanford	Date 3/17/07				Rev c
Program Manager: J. Sanford	Date 3/17/07				

10.0 10 MHz EXTERNAL REFERENCE

This test will insure that the receiver can be commanded to select either the external or the internal reference, and that it will lock to the external reference signal within the specified input power limits of 0 dBm ± 2 dBm. *Stability and accuracy requirements for the internal reference are not specified.*

Refer to Figure 10-1 for test configuration.

10.1 Select the external reference

10.2 Tune the receiver to 436.500000 MHz.

10.3 Set signal generator #1 to 436.500000 MHz, -50 dBm

10.4 Set signal generator #2 to 10.000000 MHz, 0 dBm

10.5 ► Record the I.F. output frequency displayed on the Frequency Counter.

10.6 ► Increase the output level of signal generator #2 to +2 dBm. The I.F. output frequency must not vary. Record the results in the data sheet.

10.7 ► Decrease the output level of signal generator #2 to -2 dBm. The I.F. output frequency must not vary. Record the results in the data sheet.

10.8 Select the internal reference.

10.9 ► Note the new I.F. output frequency in the data sheet.

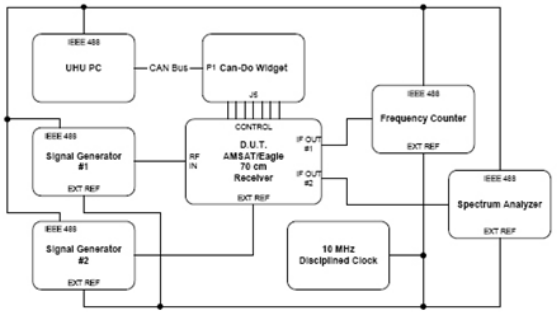
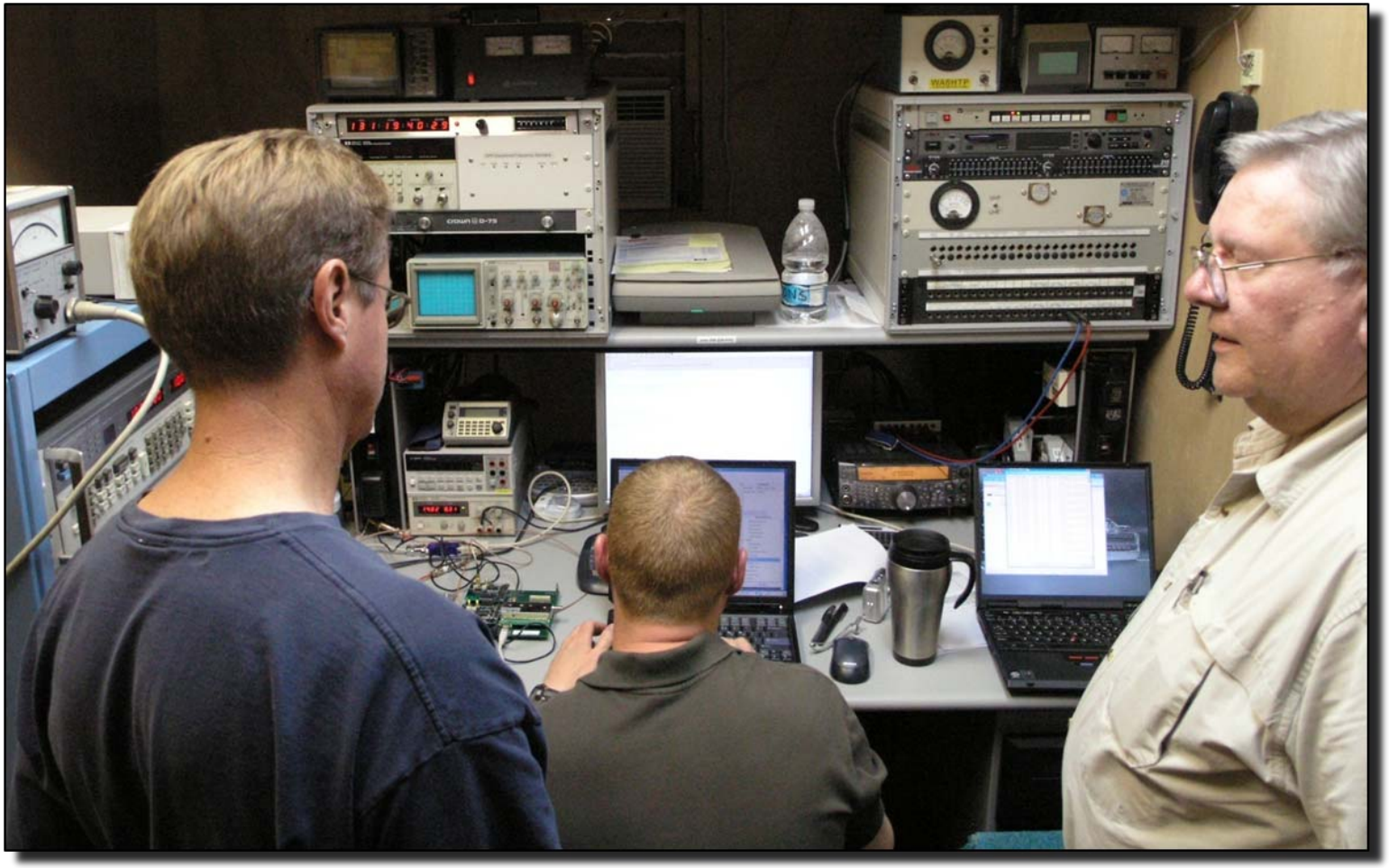


Figure 10-1. 10 MHz External Reference Test Configuration

Receiver Construction

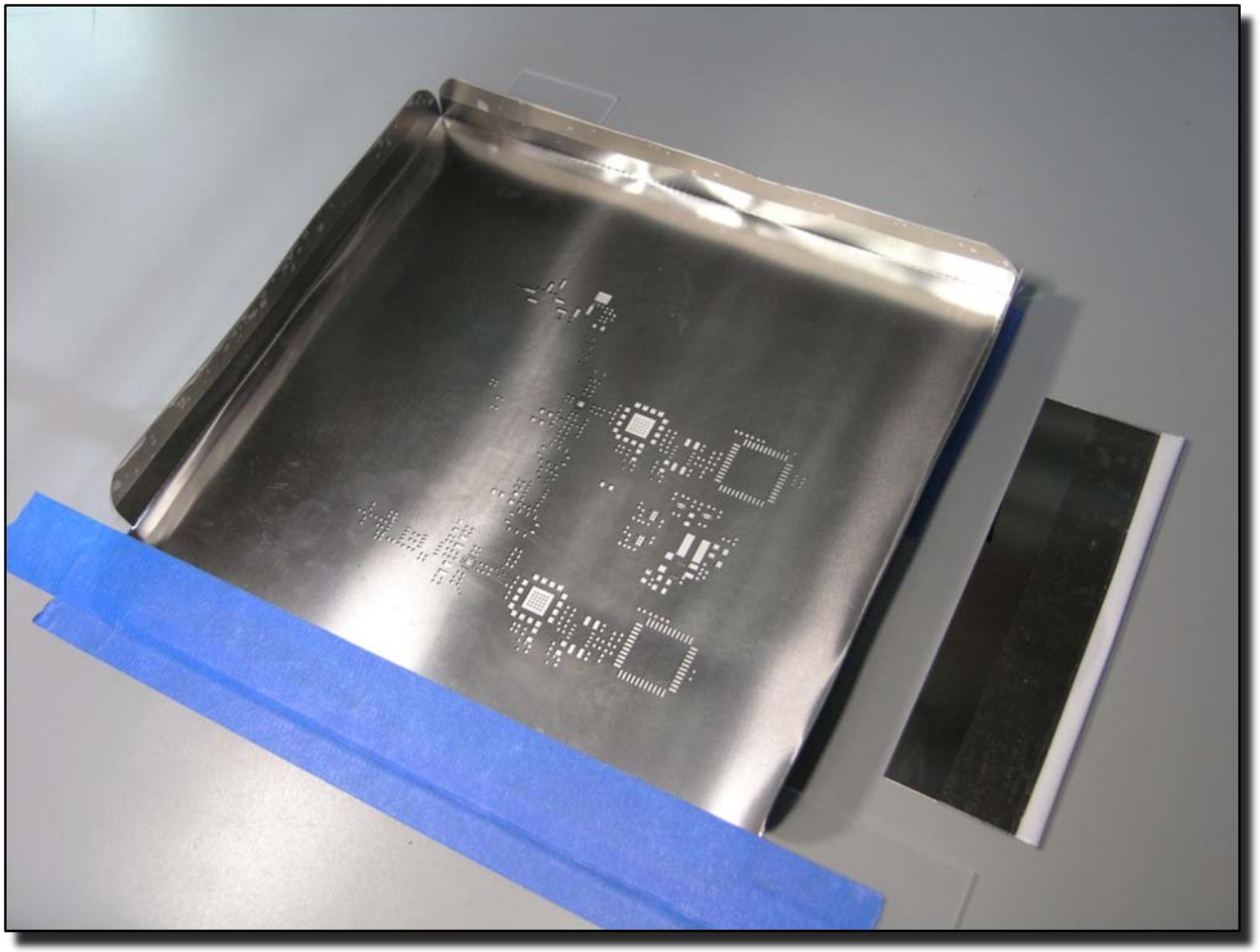
KI6IKG, N0TGD, and KD6IRE



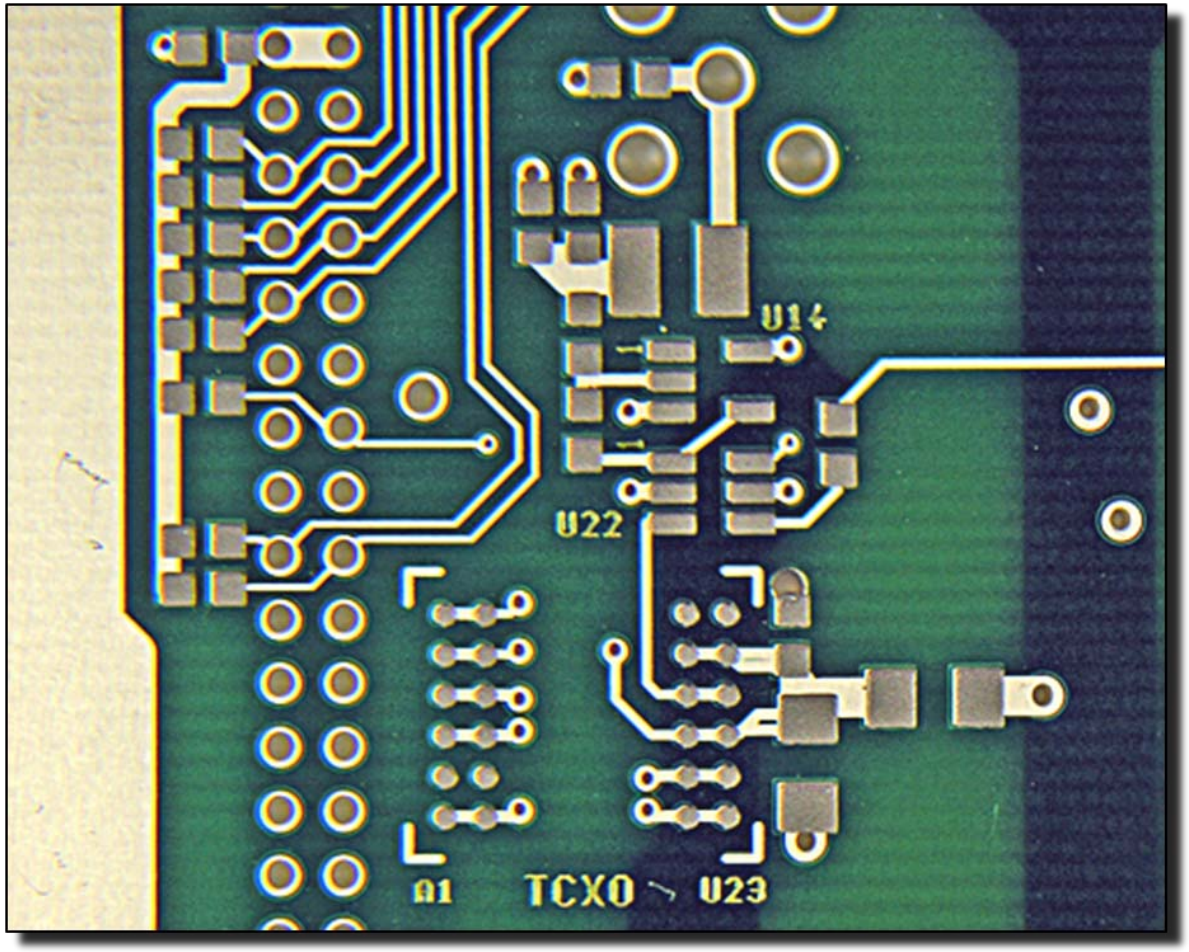
WA6HTP

Component Kitting

Solder Stencil



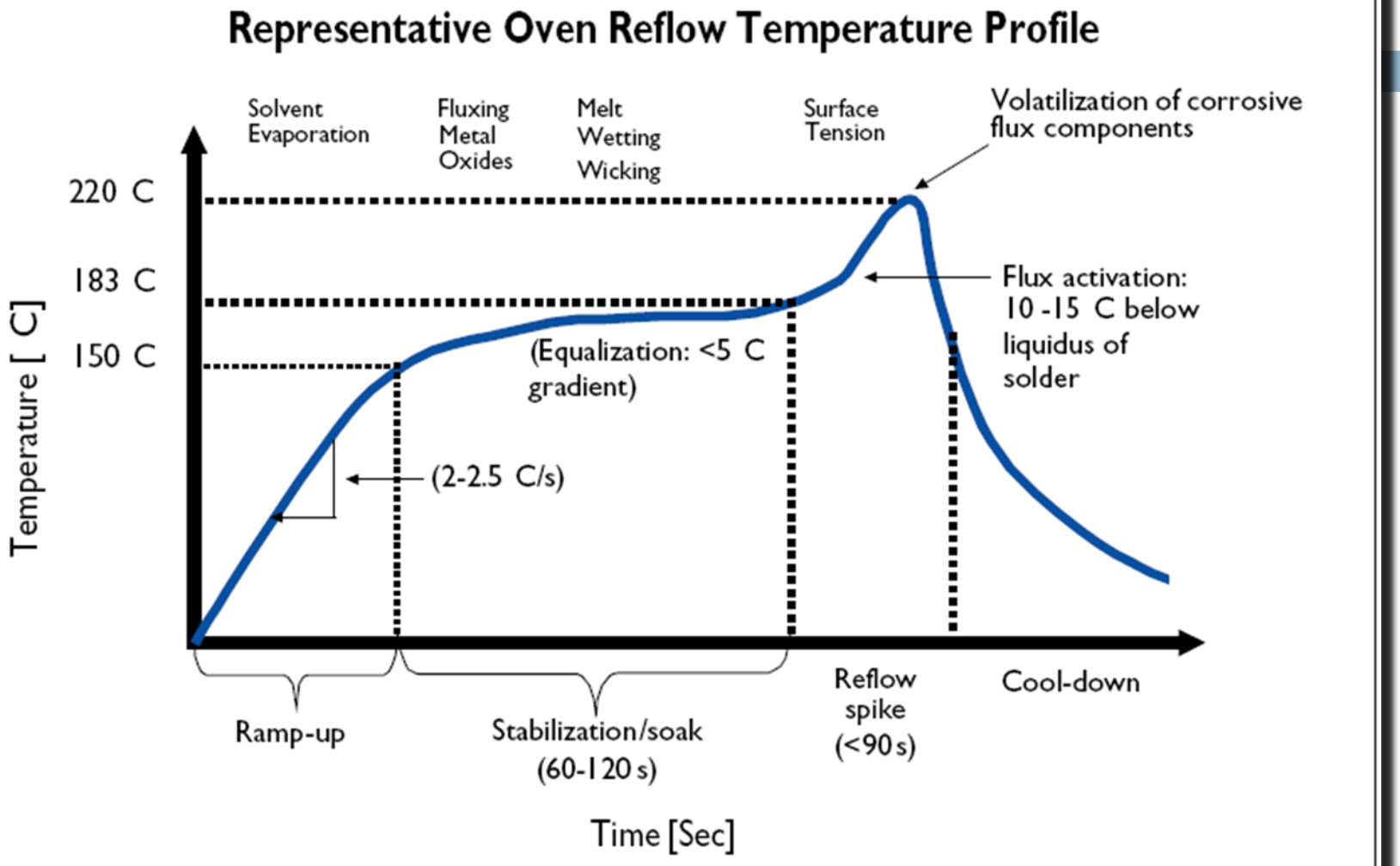
Solder Paste Applied



Placing Parts with Vacuum Pick

Reflow Soldering

- Extremely Repeatable
  - Prototype (1X)
  - Non-Flight (4X)
  - Flight Hardware (≥2X)
- Reduced Chance of Latent Defects
  - No Thermal Shock
- Requires a Fresh Way of Thinking

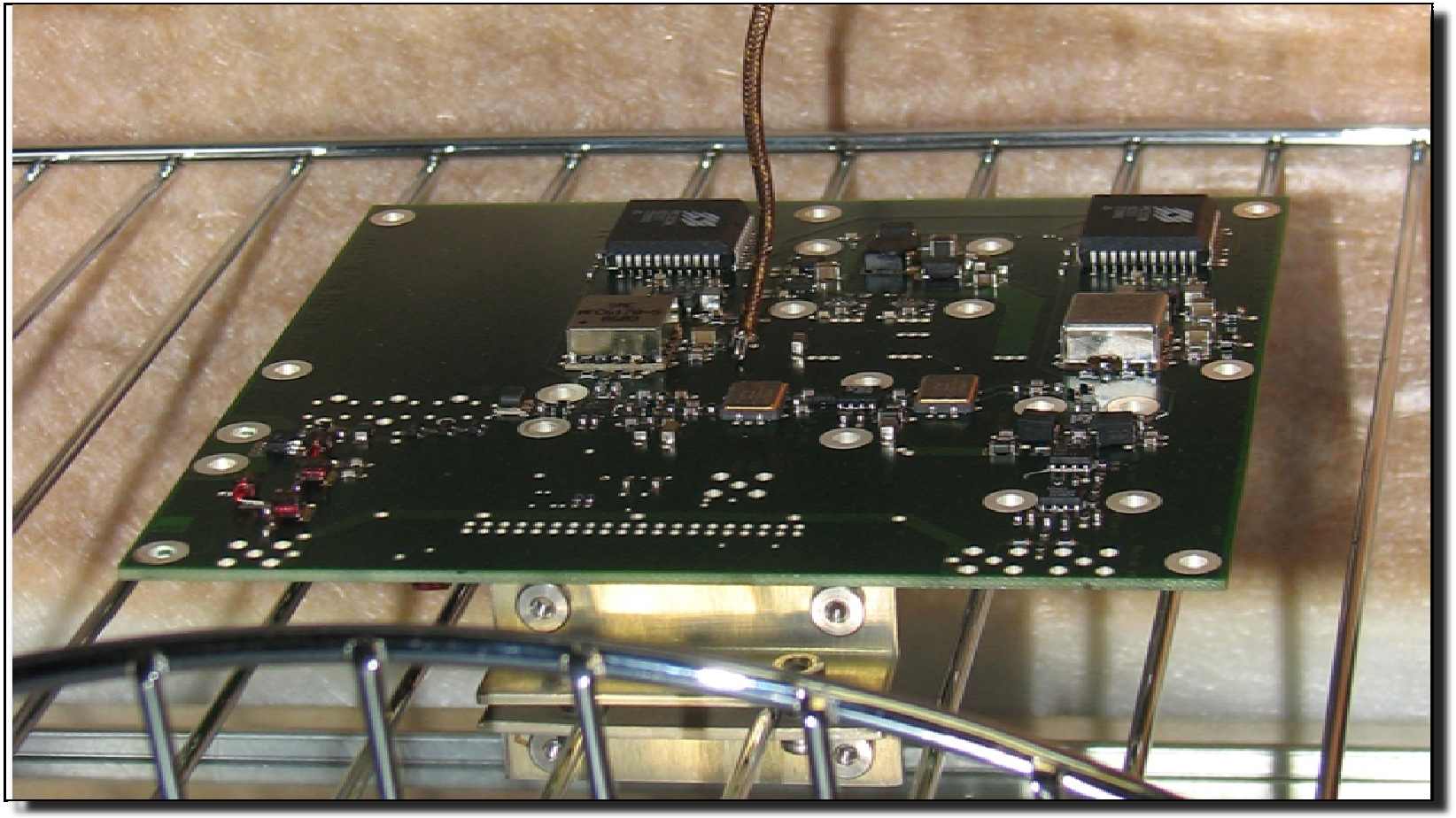


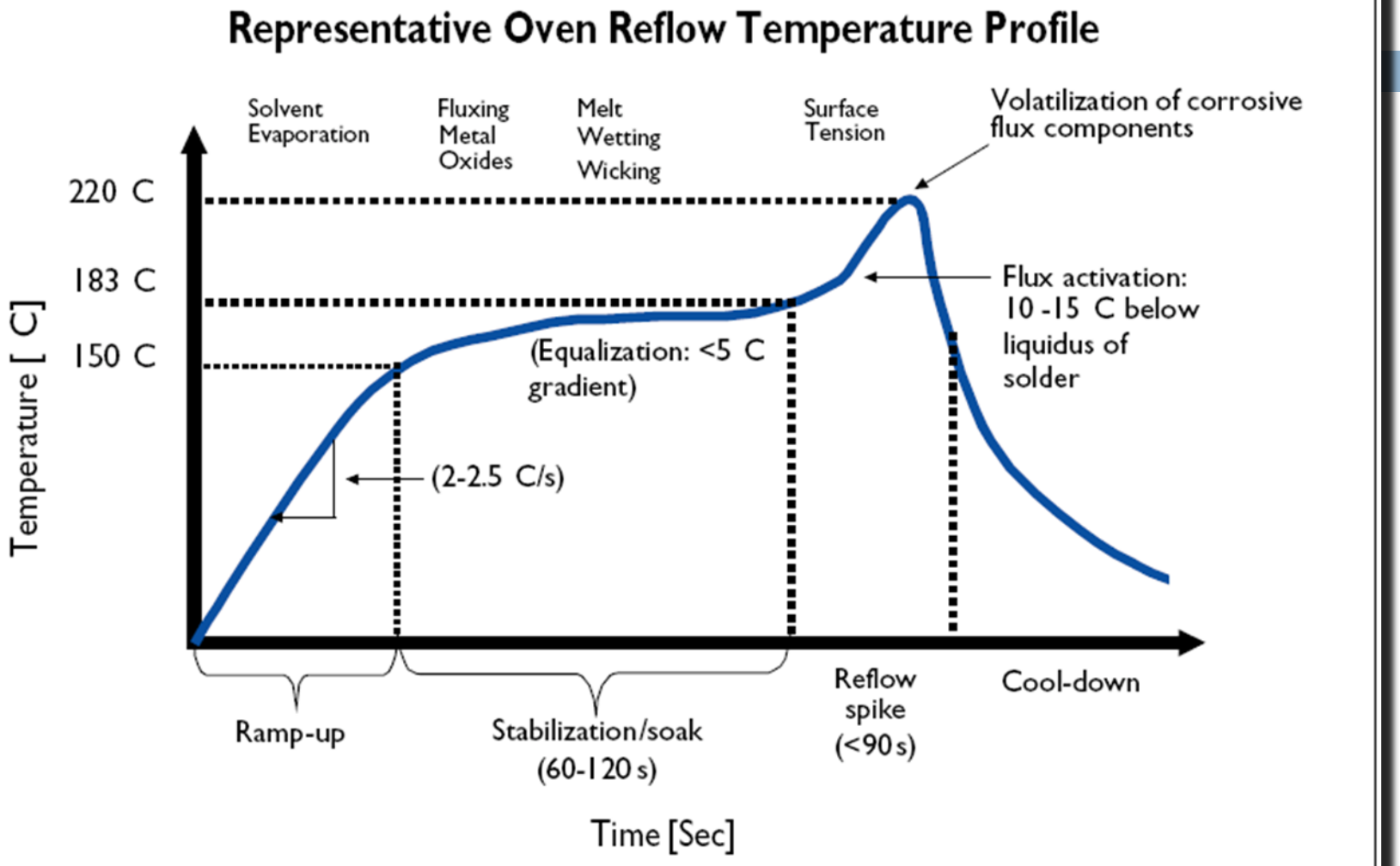
Courtesy of Bergquist Company

Reflow Oven Controller

Reflow Oven

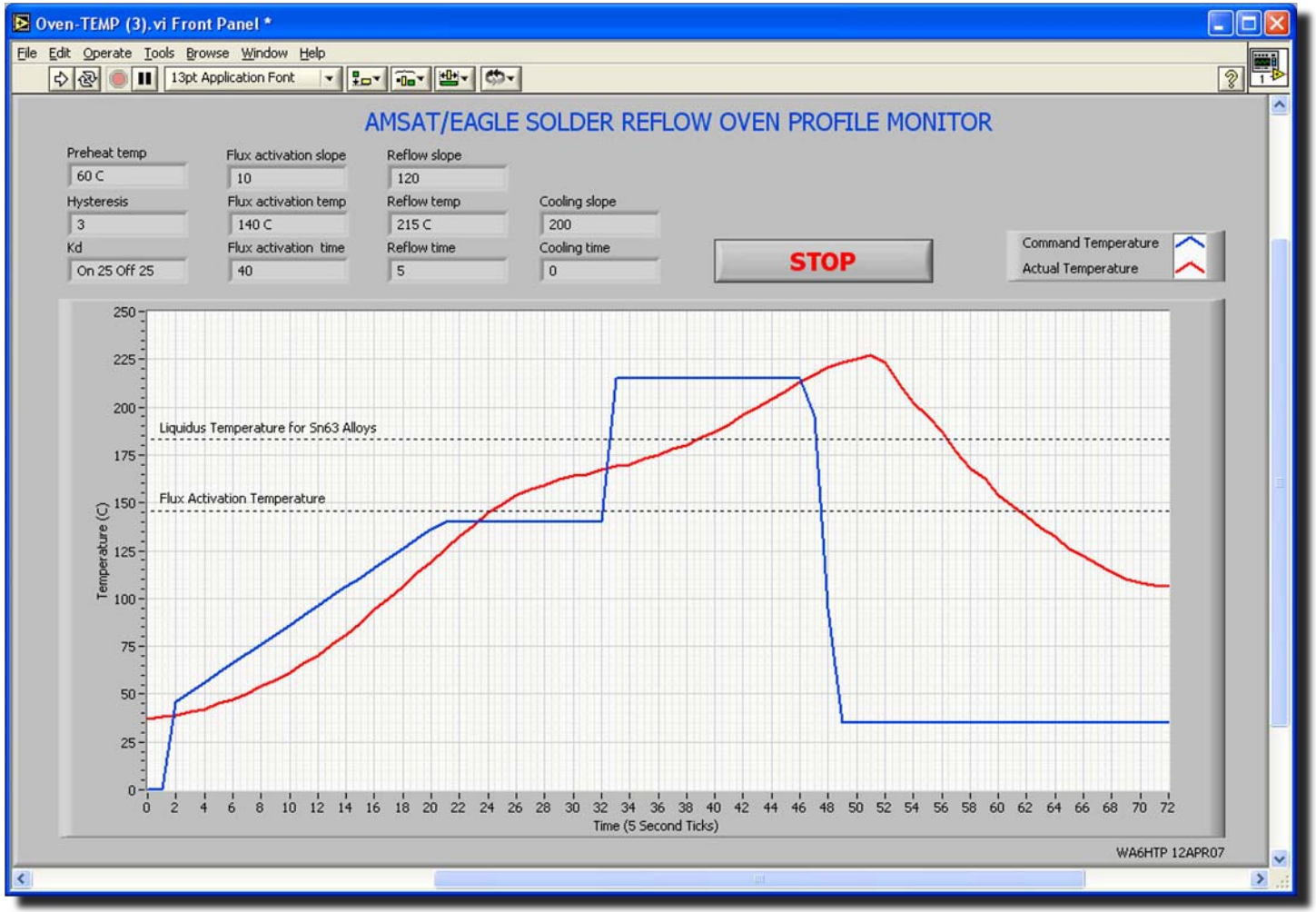
PCB In Reflow Oven



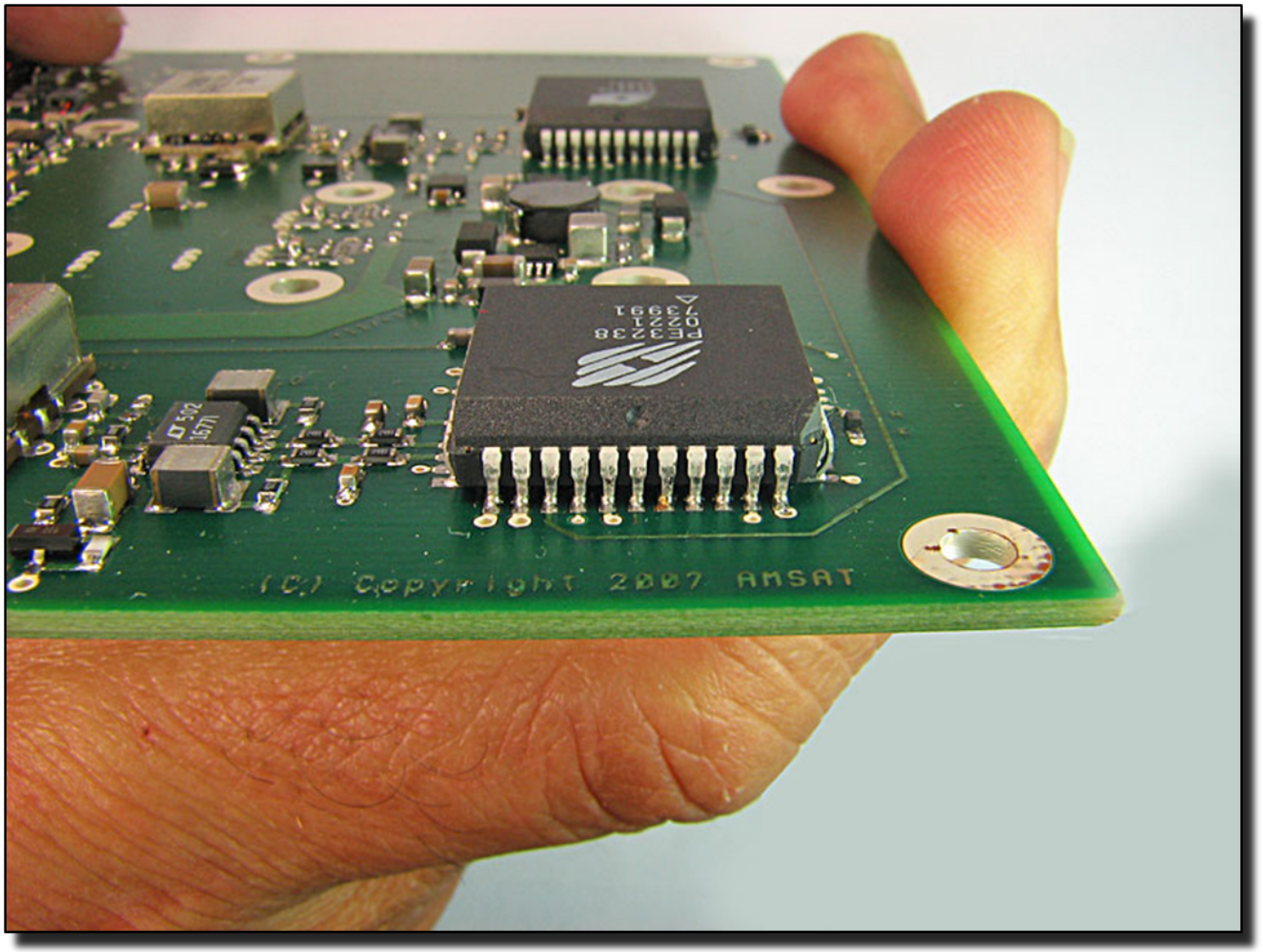


Courtesy of Bergquist Company

Reflow Oven Thermal Profile



Reflow Results

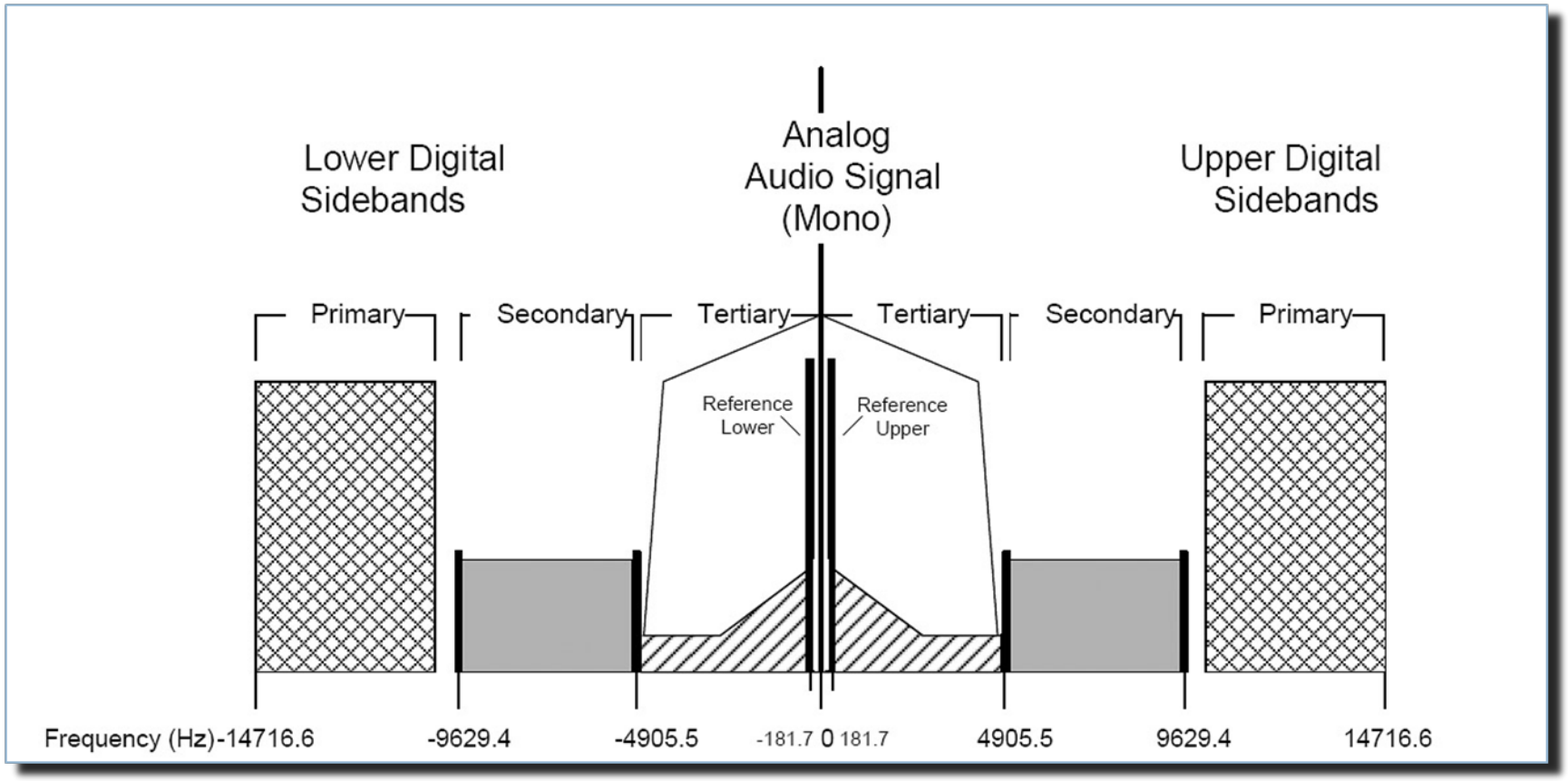


Testing

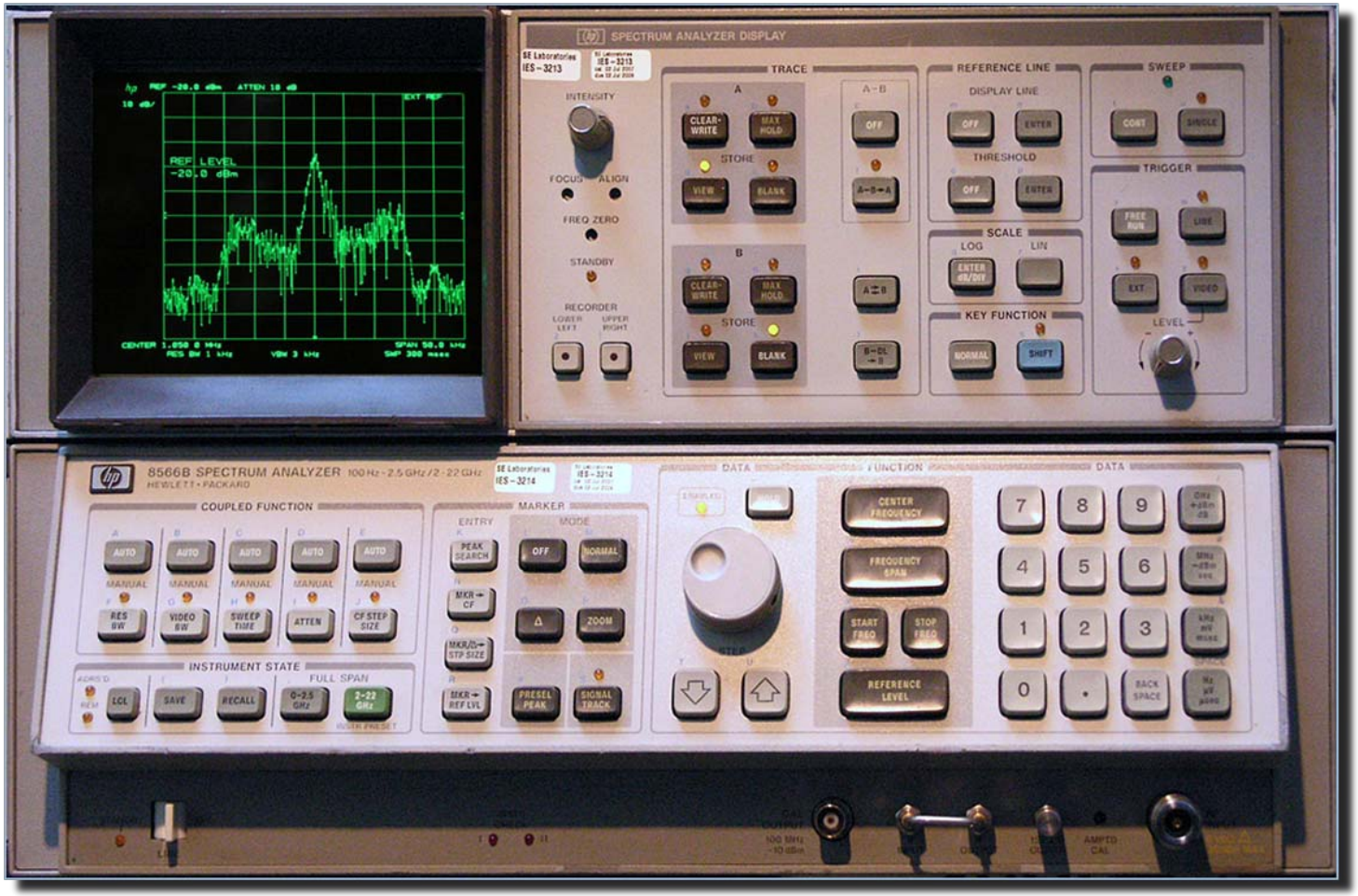
- Prototype
- Non-Flight
- Flight Hardware

Test Equipment

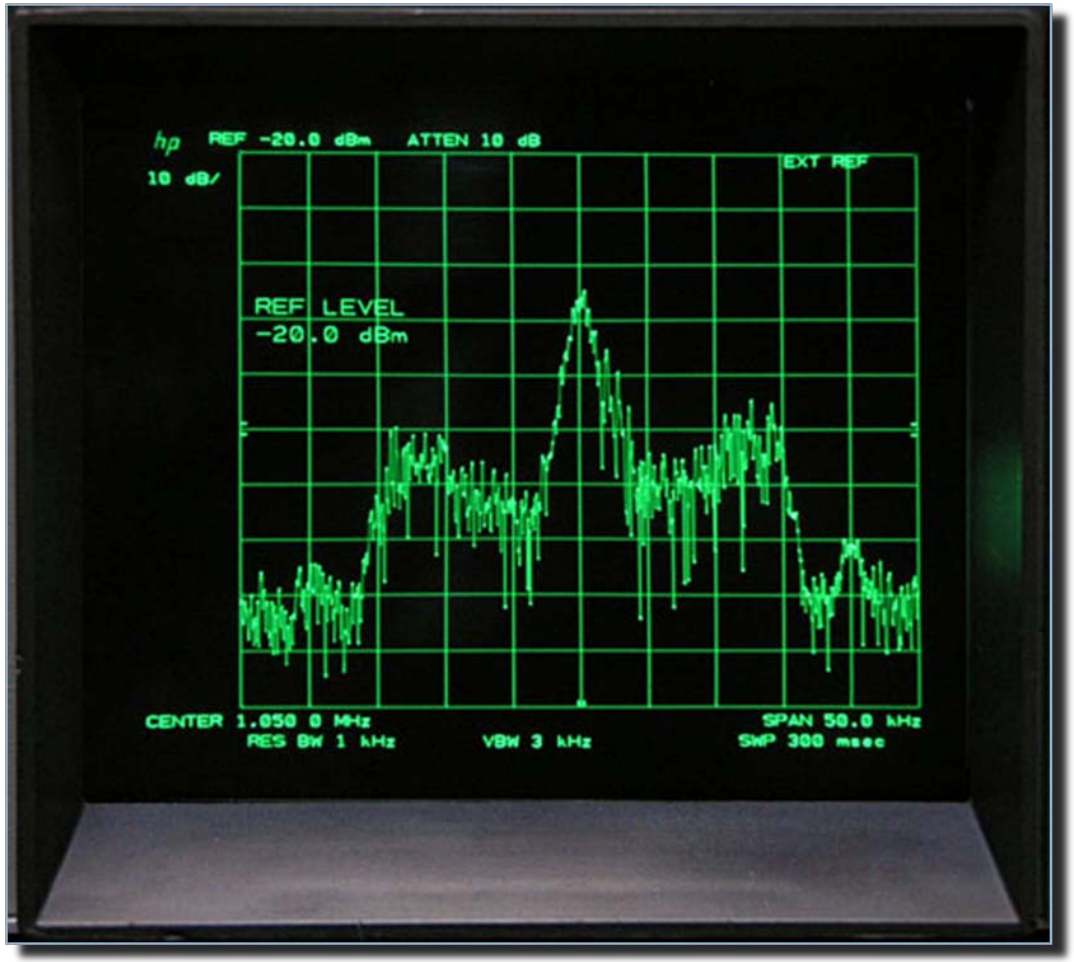
AM Broadcast IBOC Waveform



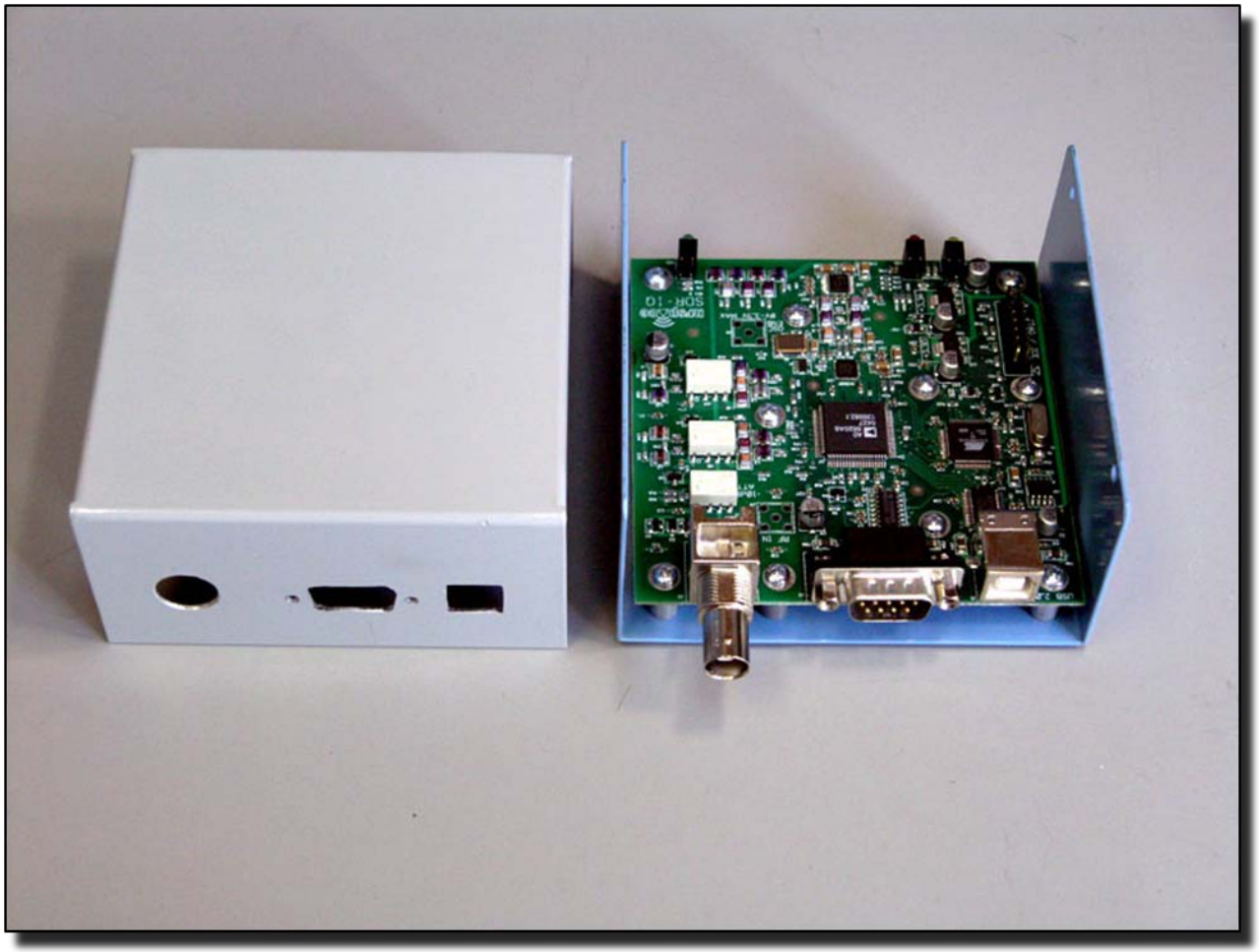
HP 8566B – (Cost in 1997: $75,800)

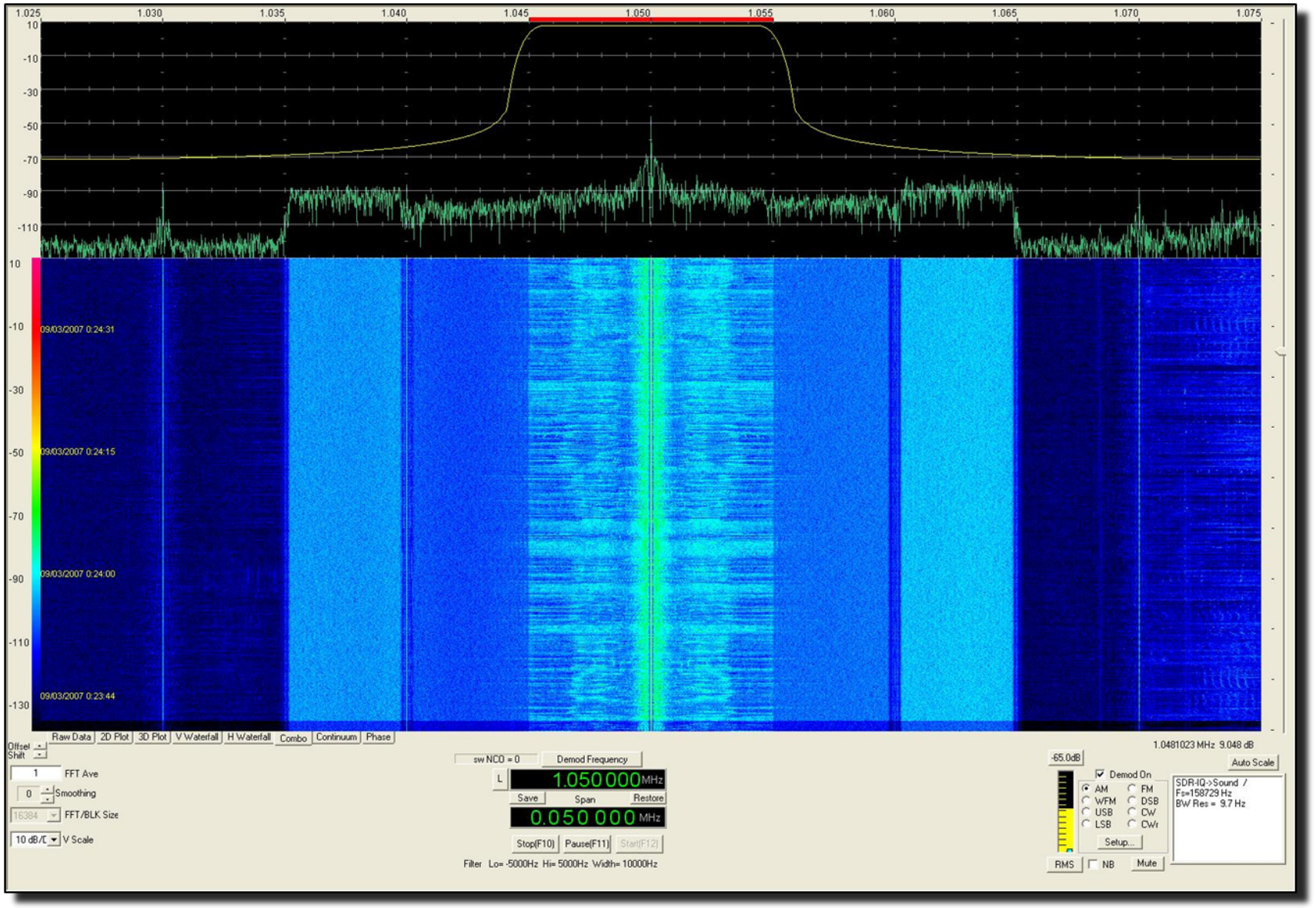


IBOC Displayed on HP 8566B

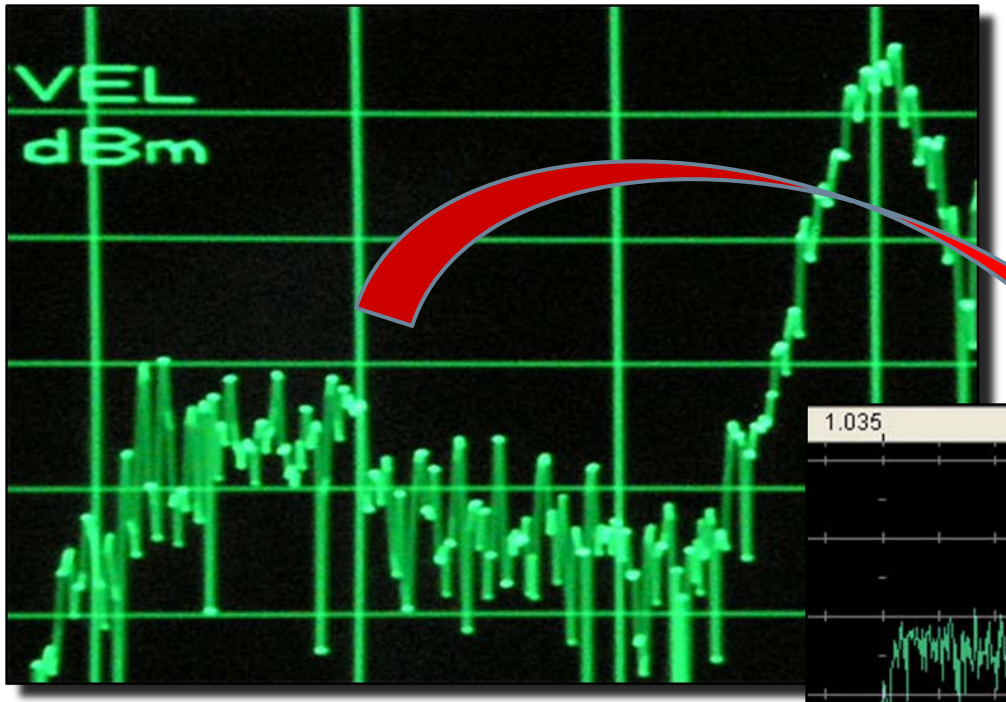


SDR-IQ – Cost in 2007: $400

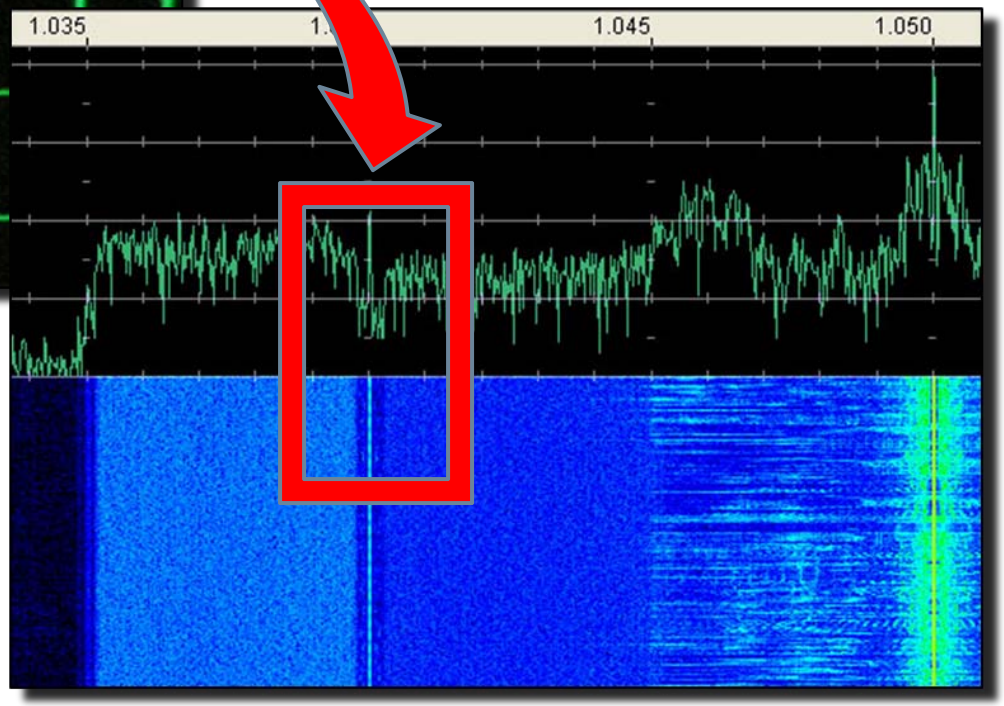



1.025
1.030
1.035
1.040
1.045
1.050
1.055
1.060
1.065
1.070
1.075
10
-10
-30
-50
-70
-90
-110
09/03/2007 0:24:31
09/03/2007 0:24:15
09/03/2007 0:24:00
09/03/2007 0:23:44
-130
Raw Data
2D Plot
3D Plot
V Waterfall
H Waterfall
Combo
Continuum
Phase
Offset
Shift
FFT Ave
Smoothing
FFT/BLK Size
V Scale
sw NCO = 0
Demod Frequency
L
1.050 000 MHz
Save
Span
Restore
0.050 000 MHz
Stop(F10)
Pause(F11)
Start(F12)
Filter Lo= -5000Hz Hi= 5000Hz Width= 10000Hz
1.0481023 MHz 9.048 dB
-65.0dB
Auto Scale
Demod On
AM
FM
WFM
DSB
USB
CW
LSB
CWr
Setup...
SDR-IQ->Sound /
Fs=158729 Hz
BW Res = 9.7 Hz
RMS
NB
Mute

$75,800



$400

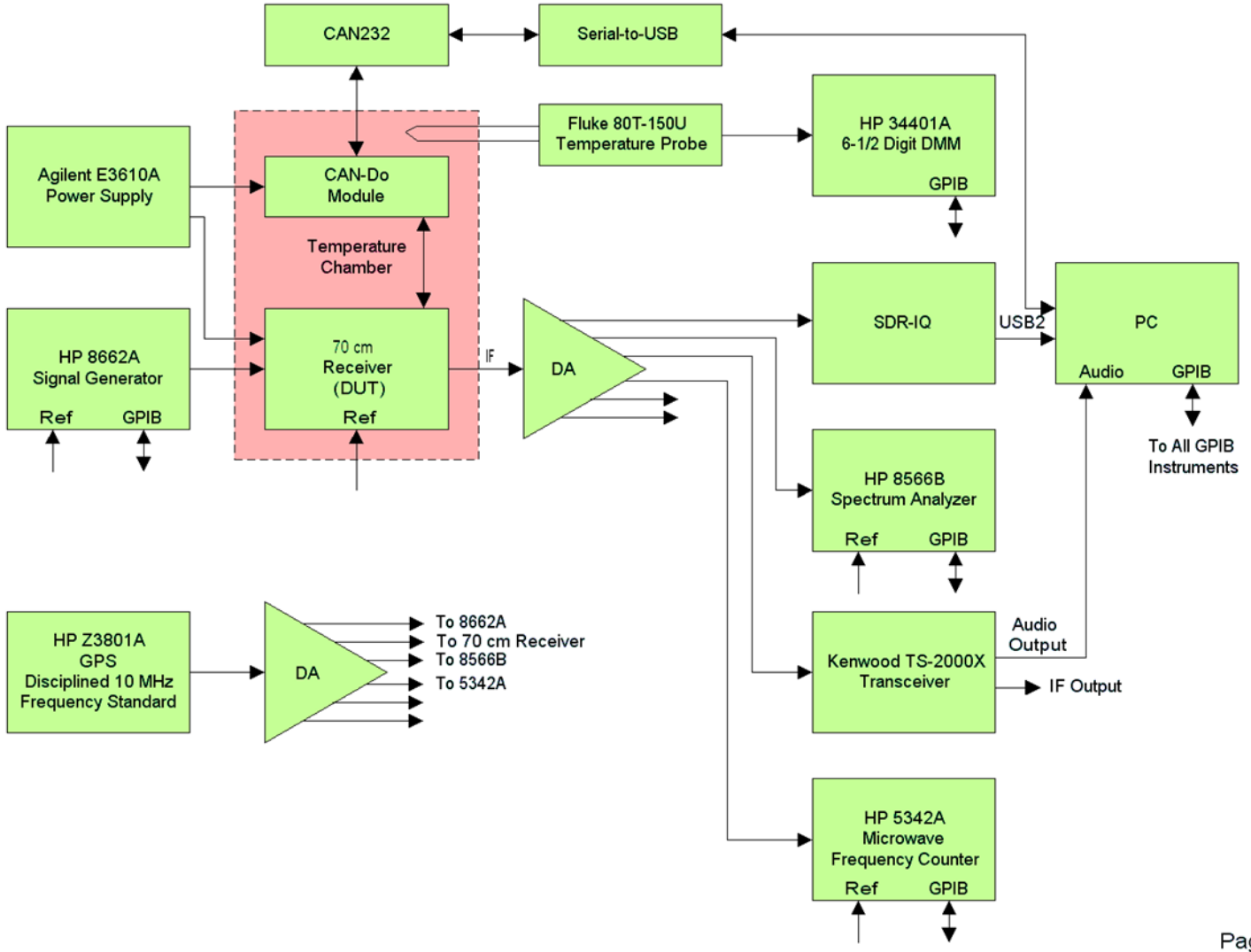


Temp. Chamber

- Dead µW Oven
- PID Controller
- Liquid CO_2 Coolant
- Quartz Heating Element
- -65^0C to $+70^0C$ $\pm 1^0C$

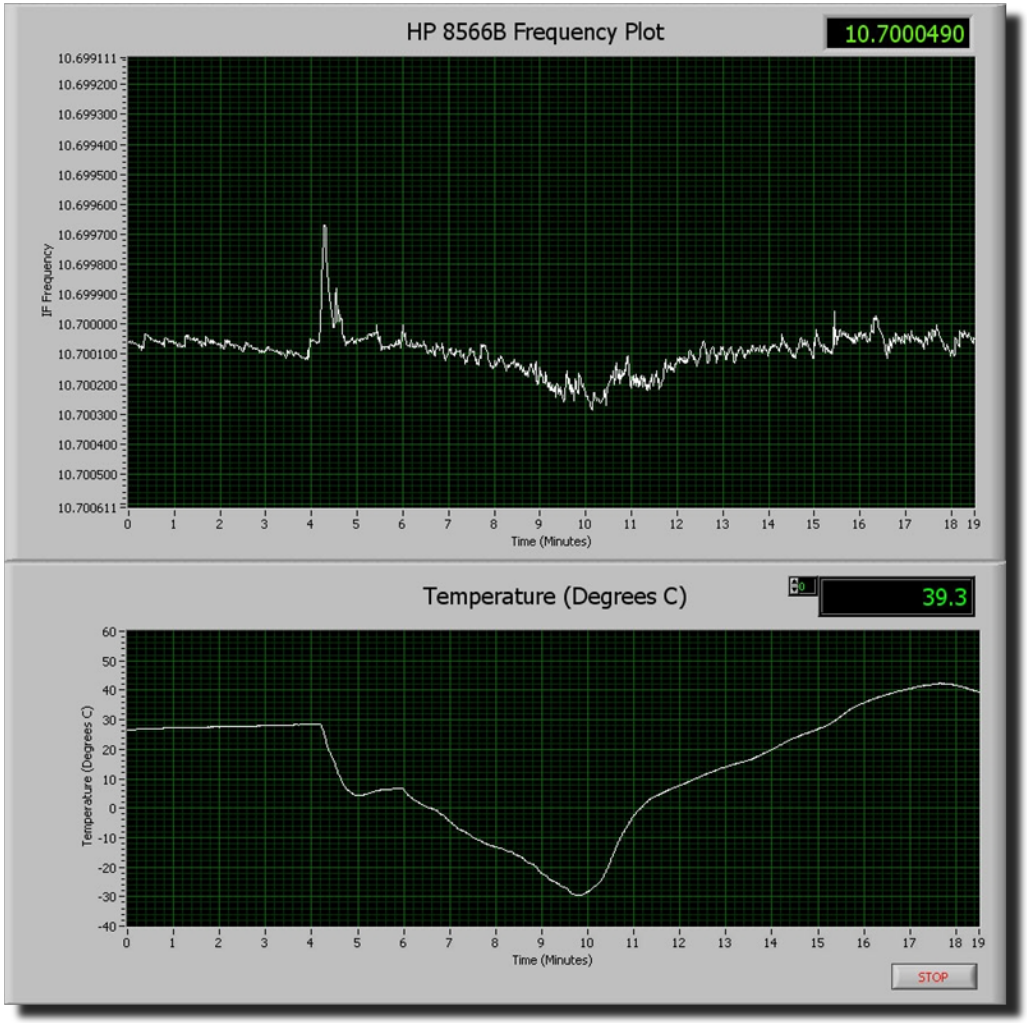
WA6HTP 70cm Eagle Receiver - Temperature Run Test Setup

Wednesday, July 04, 2007

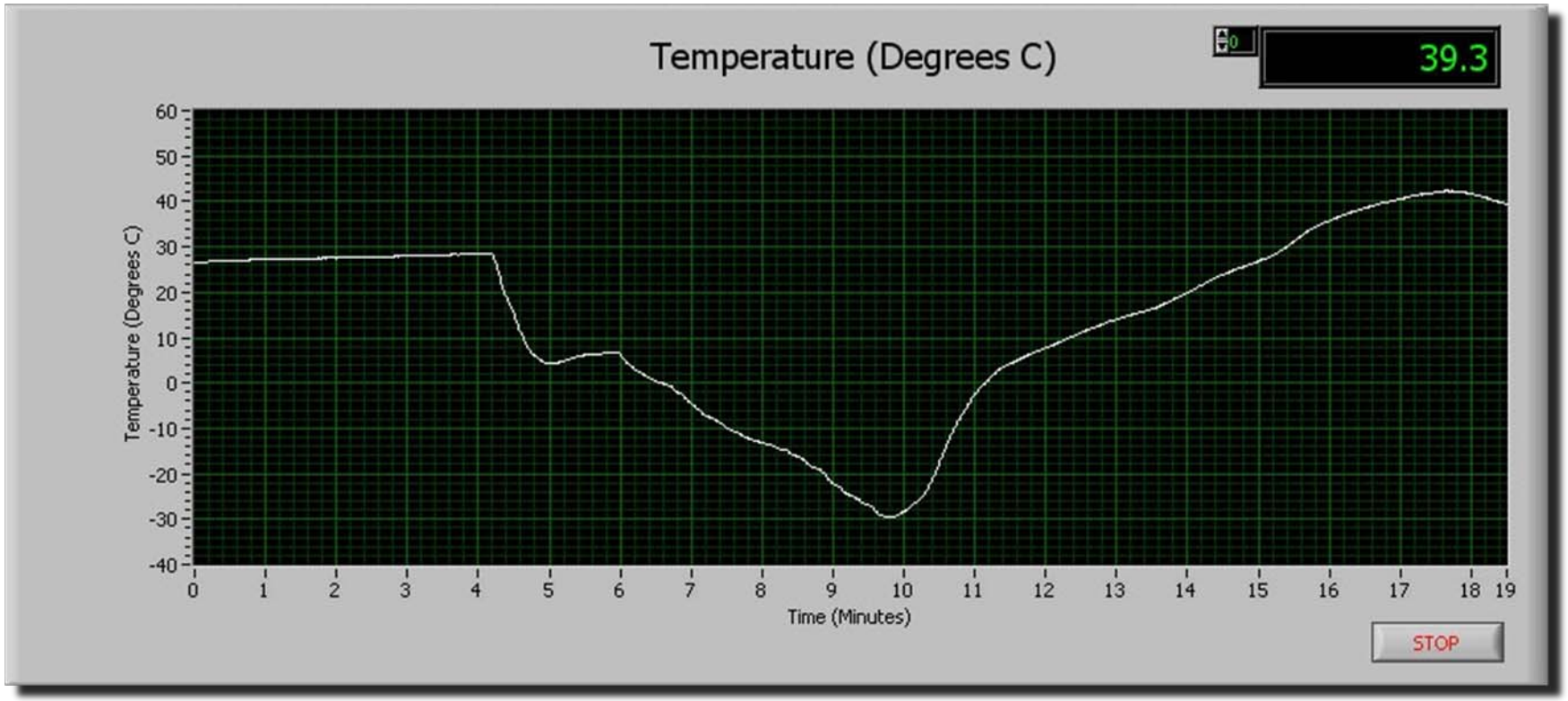


Thermal Testing

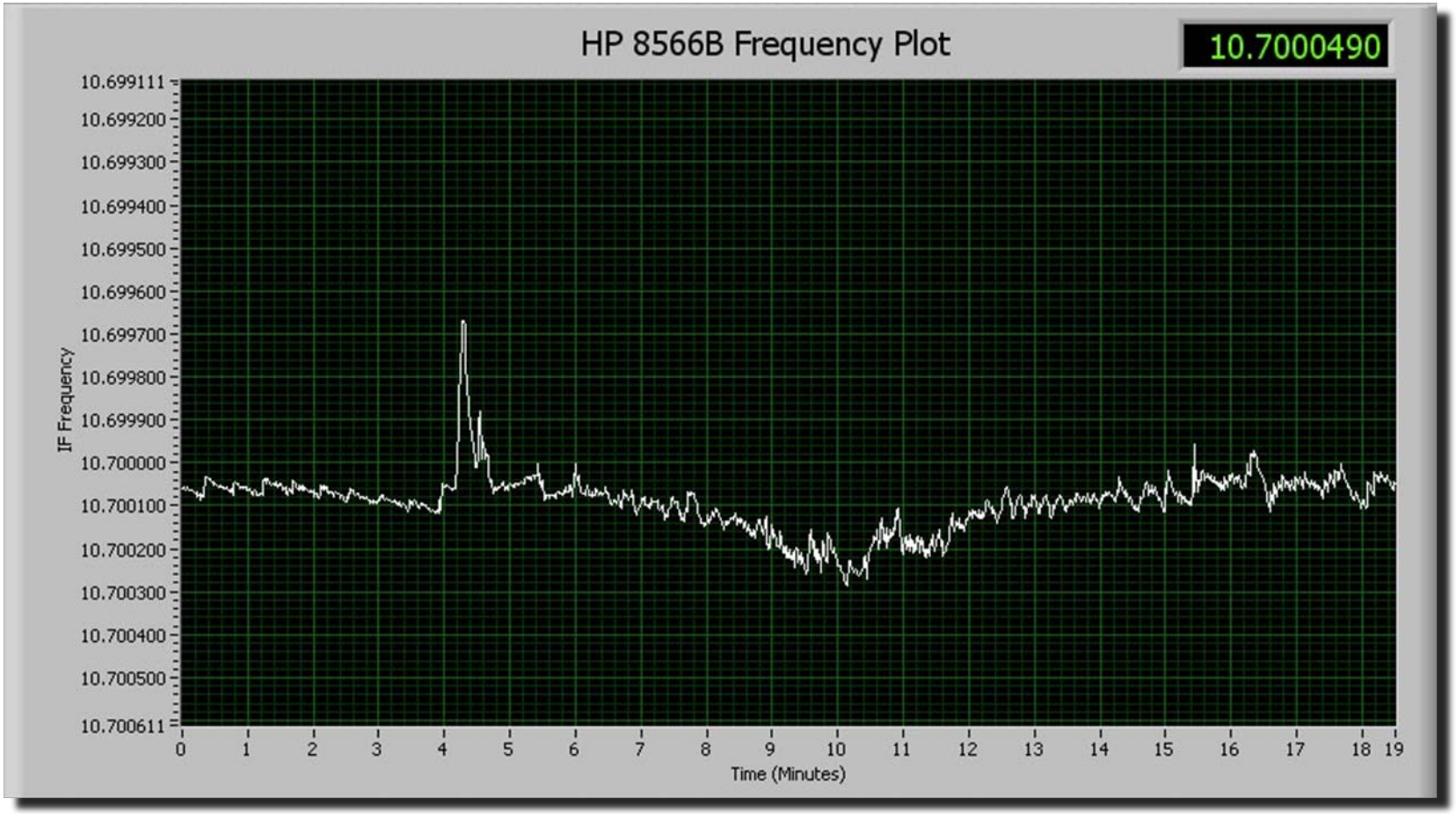
Frequency vs. Temperature



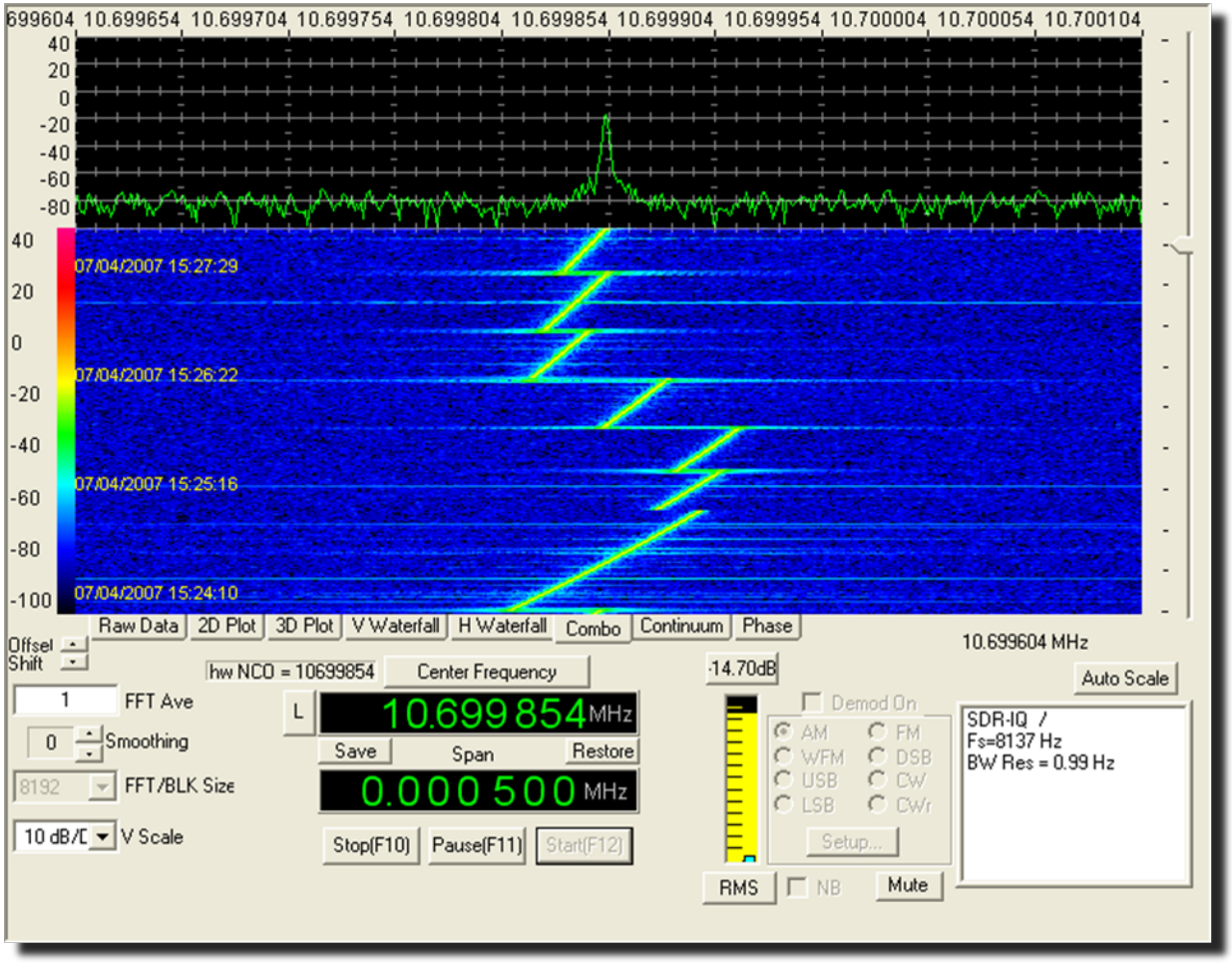
Temperature Profile



Frequency vs. Temperature



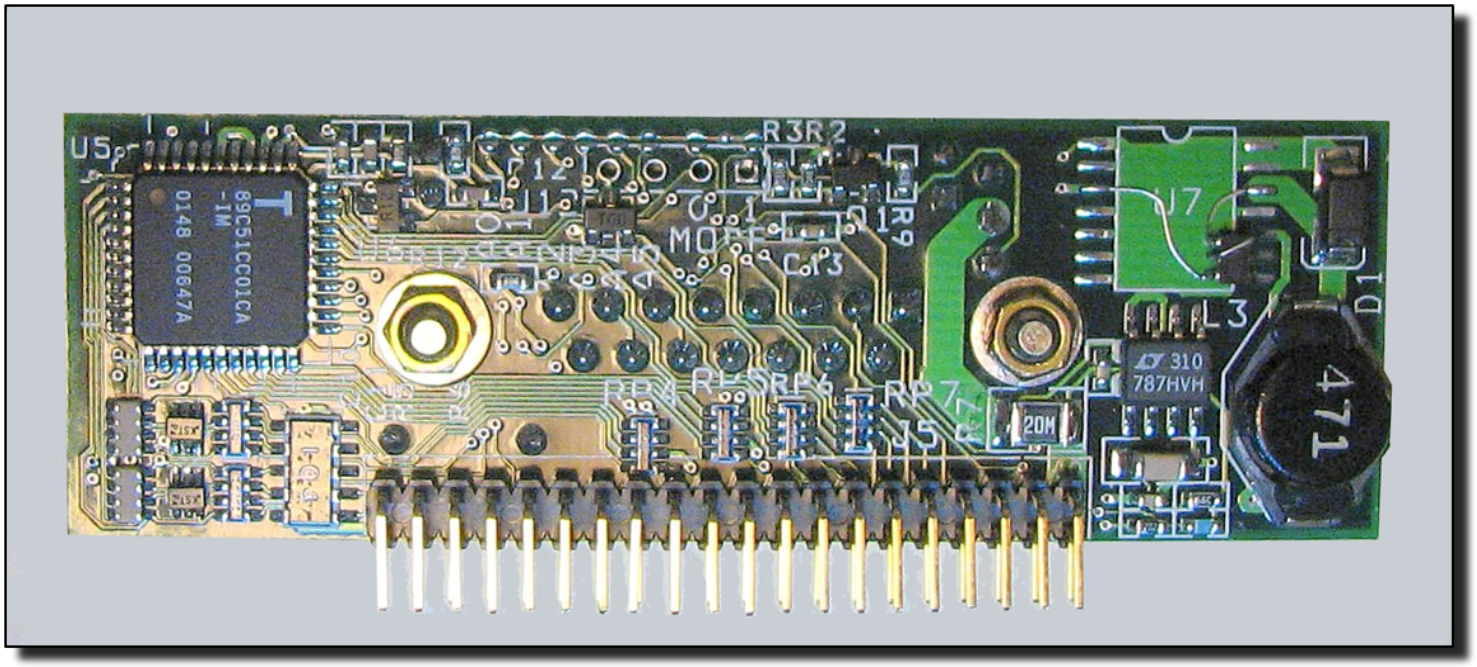
Digital TCXO Temp. Compensation



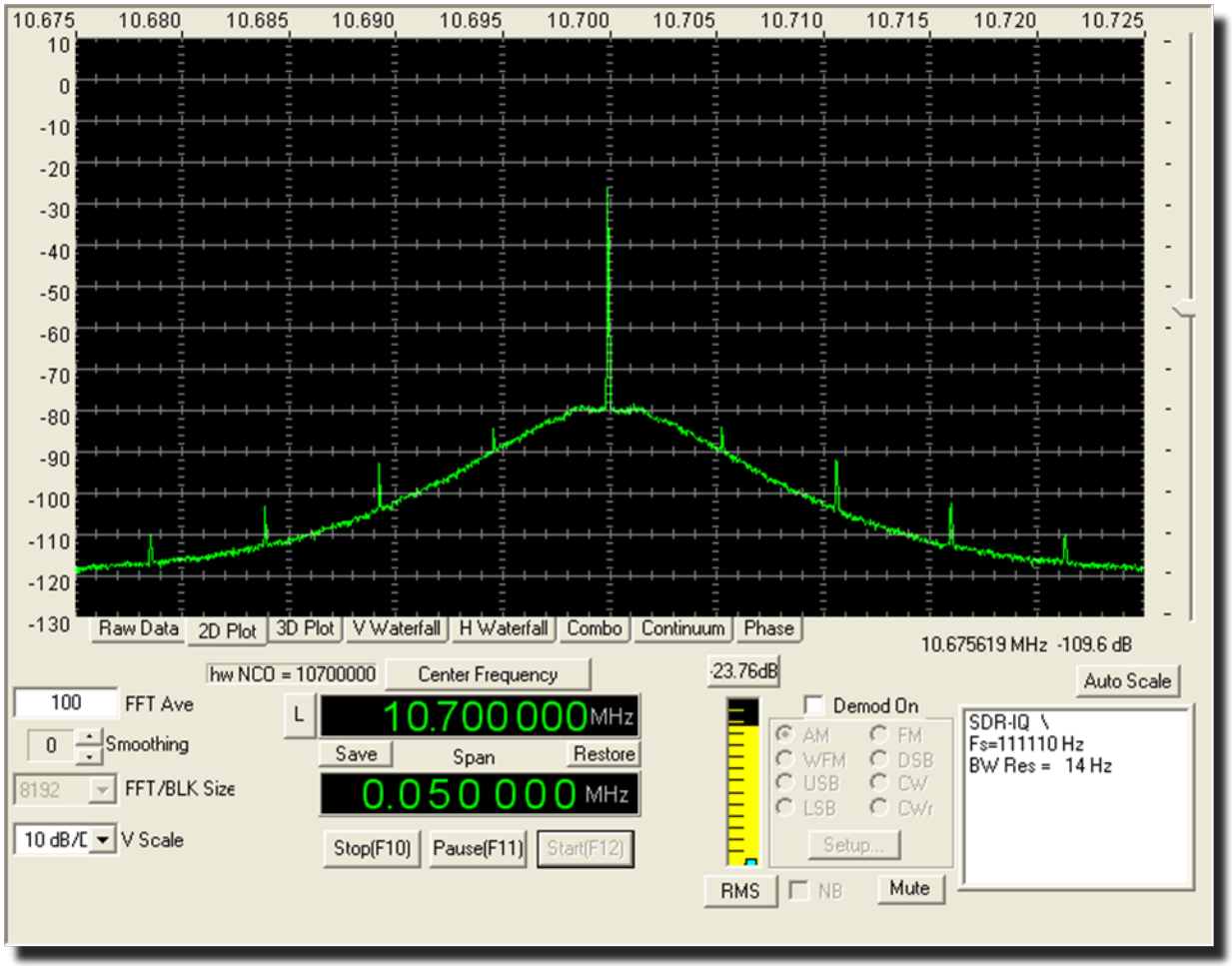
CAN-Do EMI

Radiated and Conducted EMI are a Problem

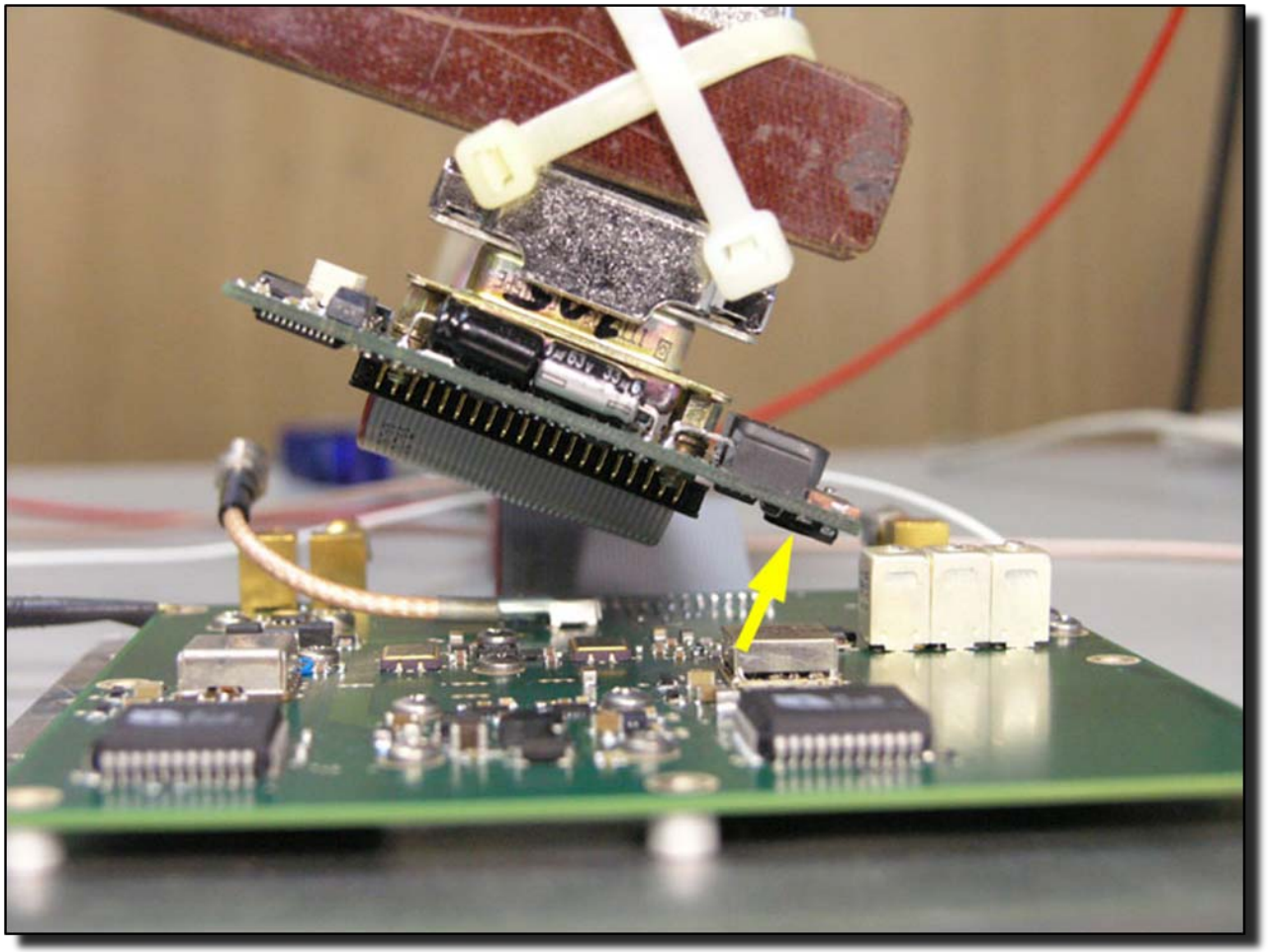
CAN-Do Module (Rear View)



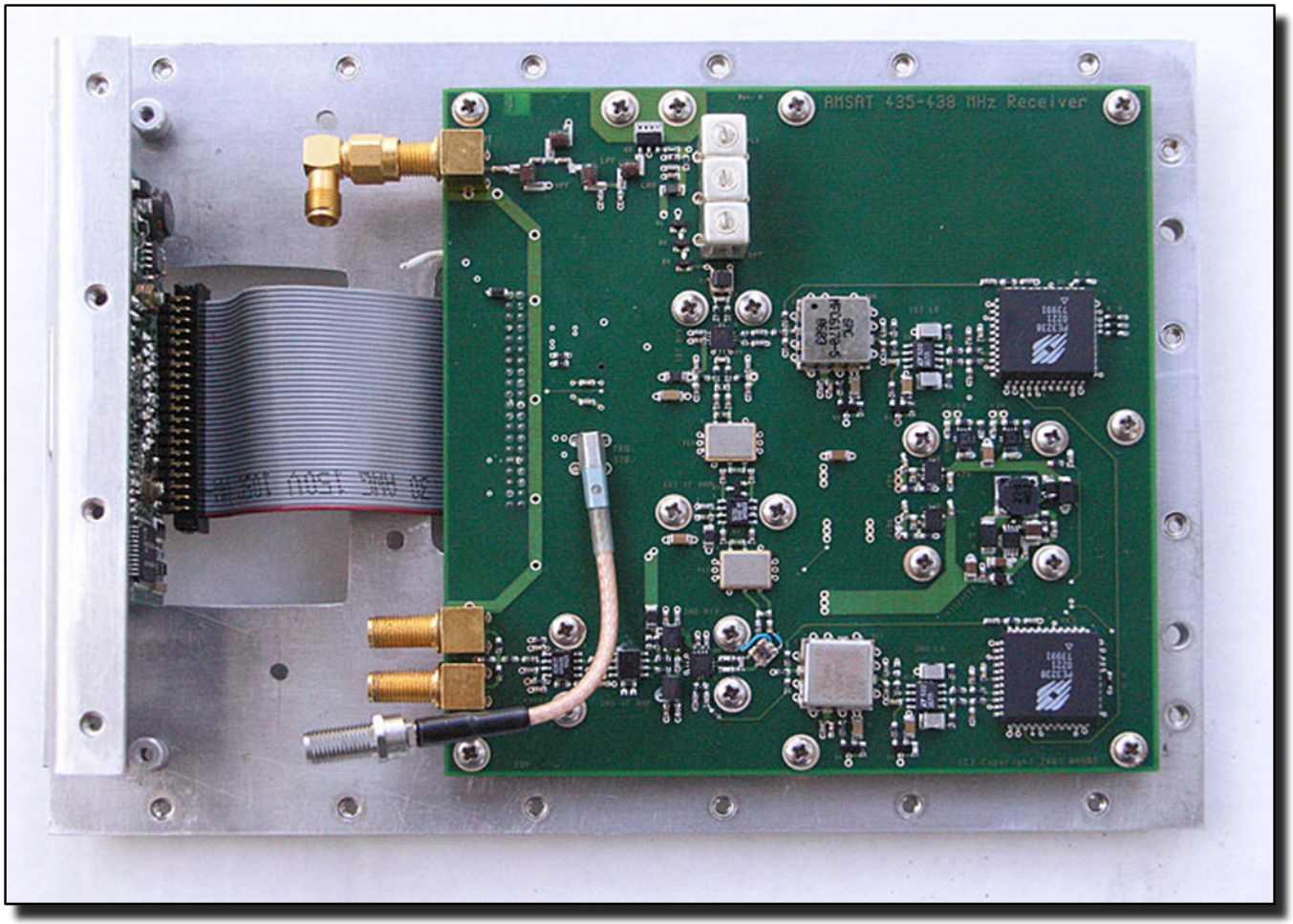
CAN-Do 5 kHz EMI



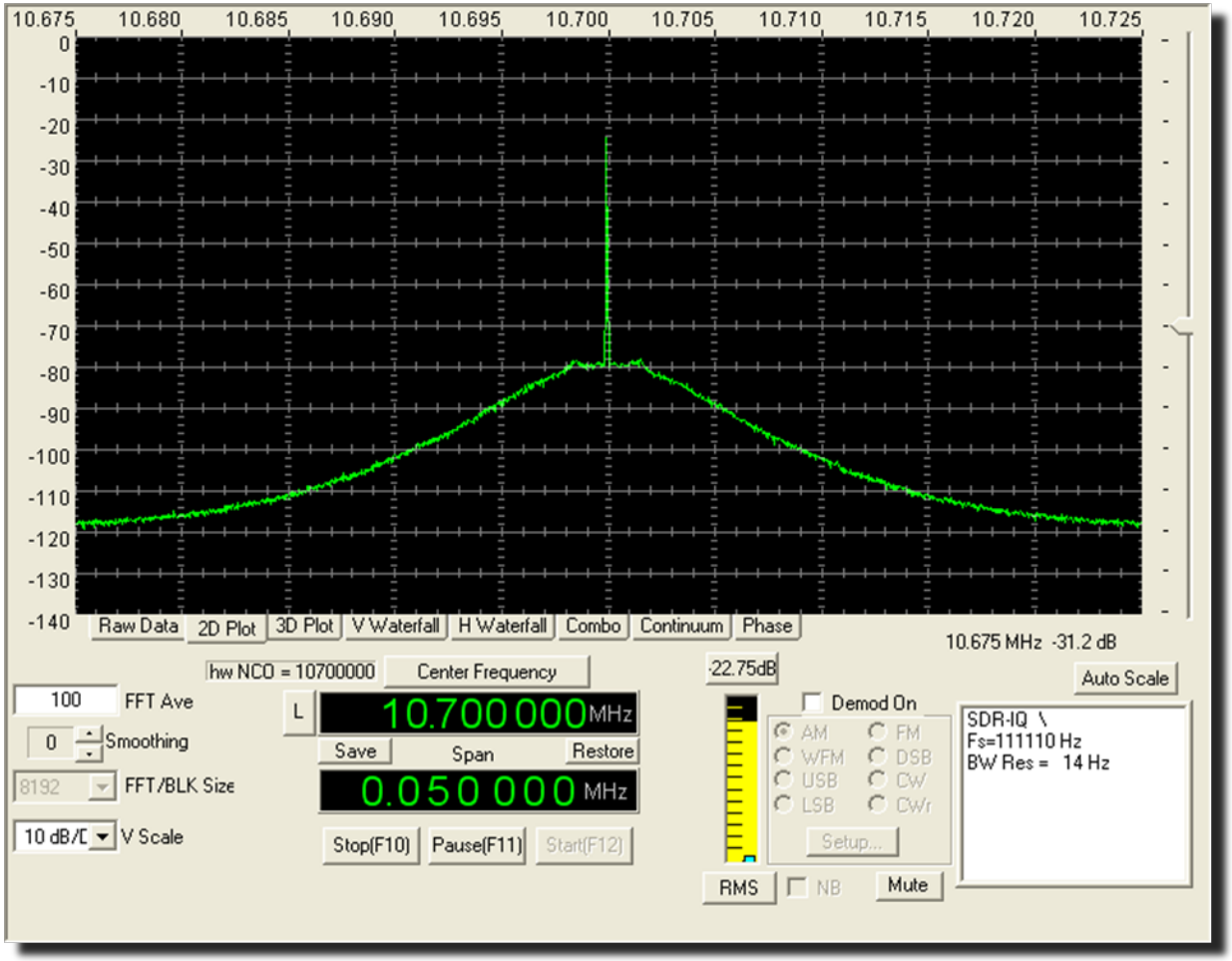
Can-Do EMI Test Fixture



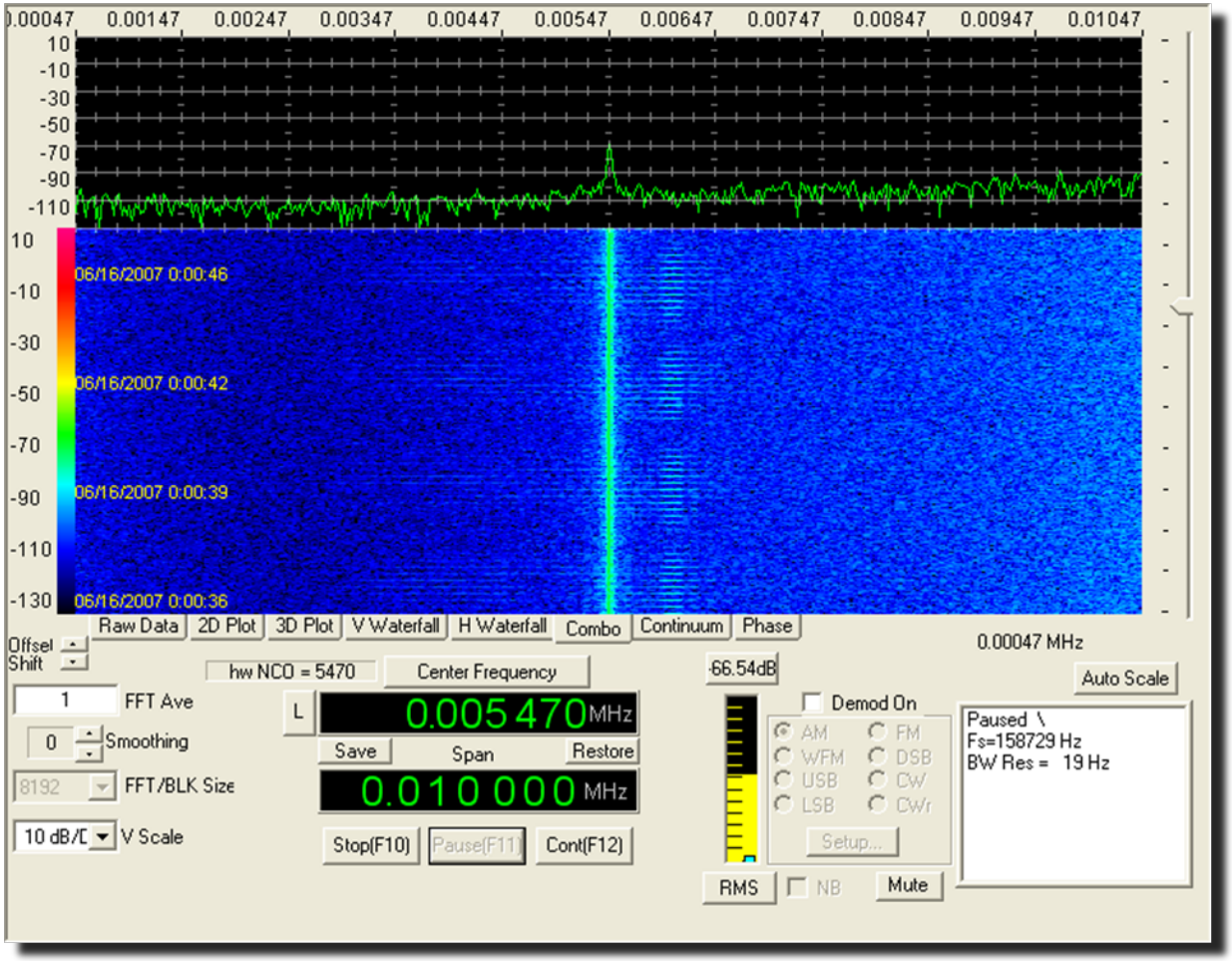
Modified Configuration



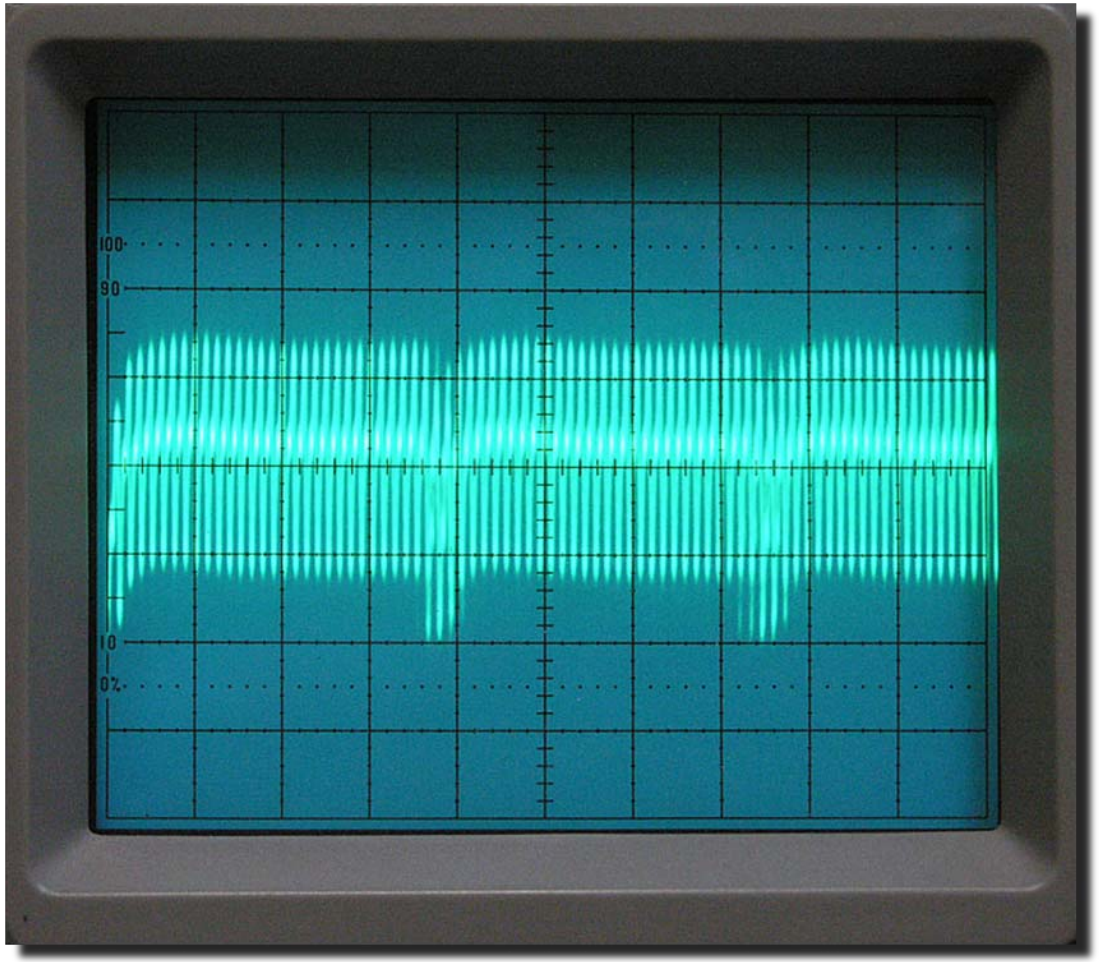
After Moving Away From CAN-Do



CAN-Do Motorboating



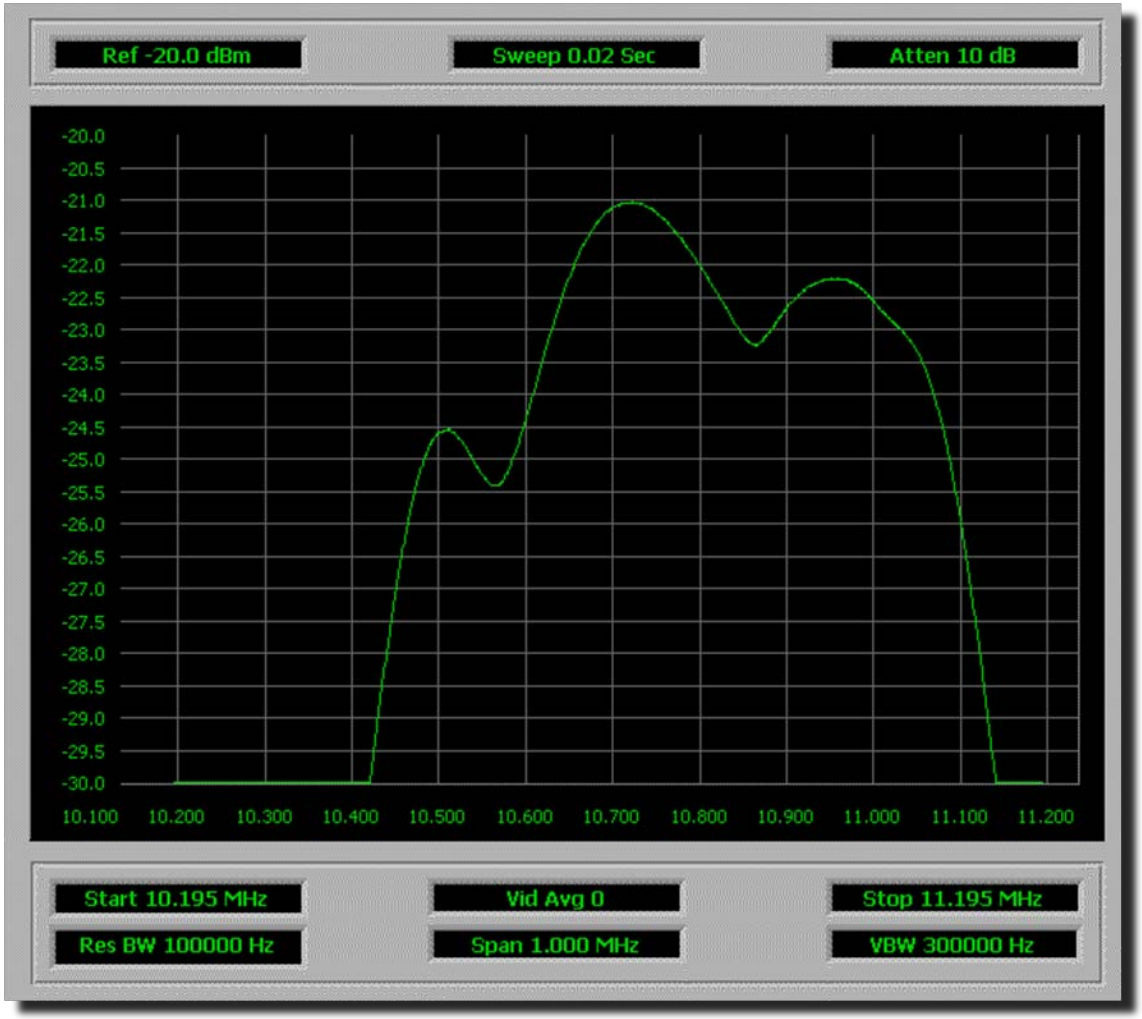
CAN-Do Conducted EMI



Passband Ripple

Problems with the Matching Networks

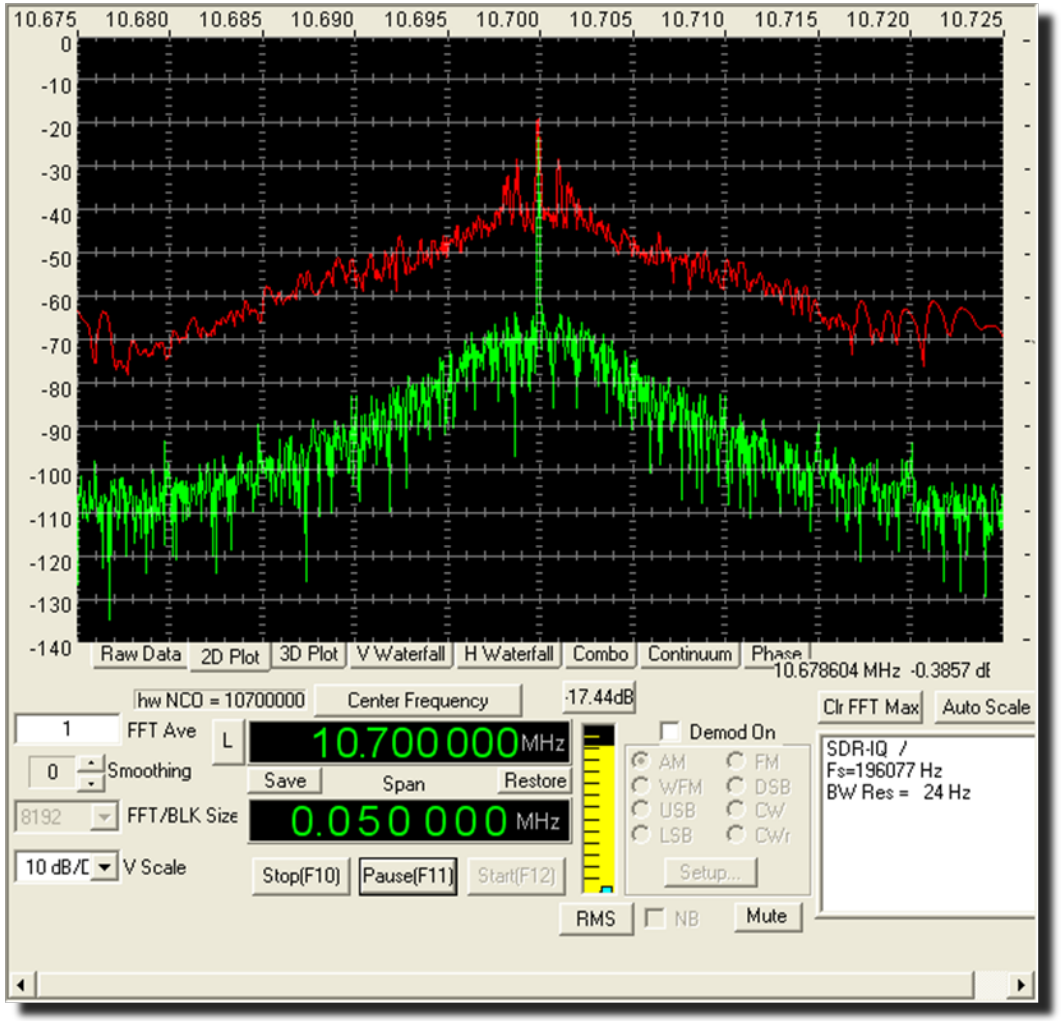
Passband Ripple



Microphonics

Caused by Ceramic Chip Capacitors

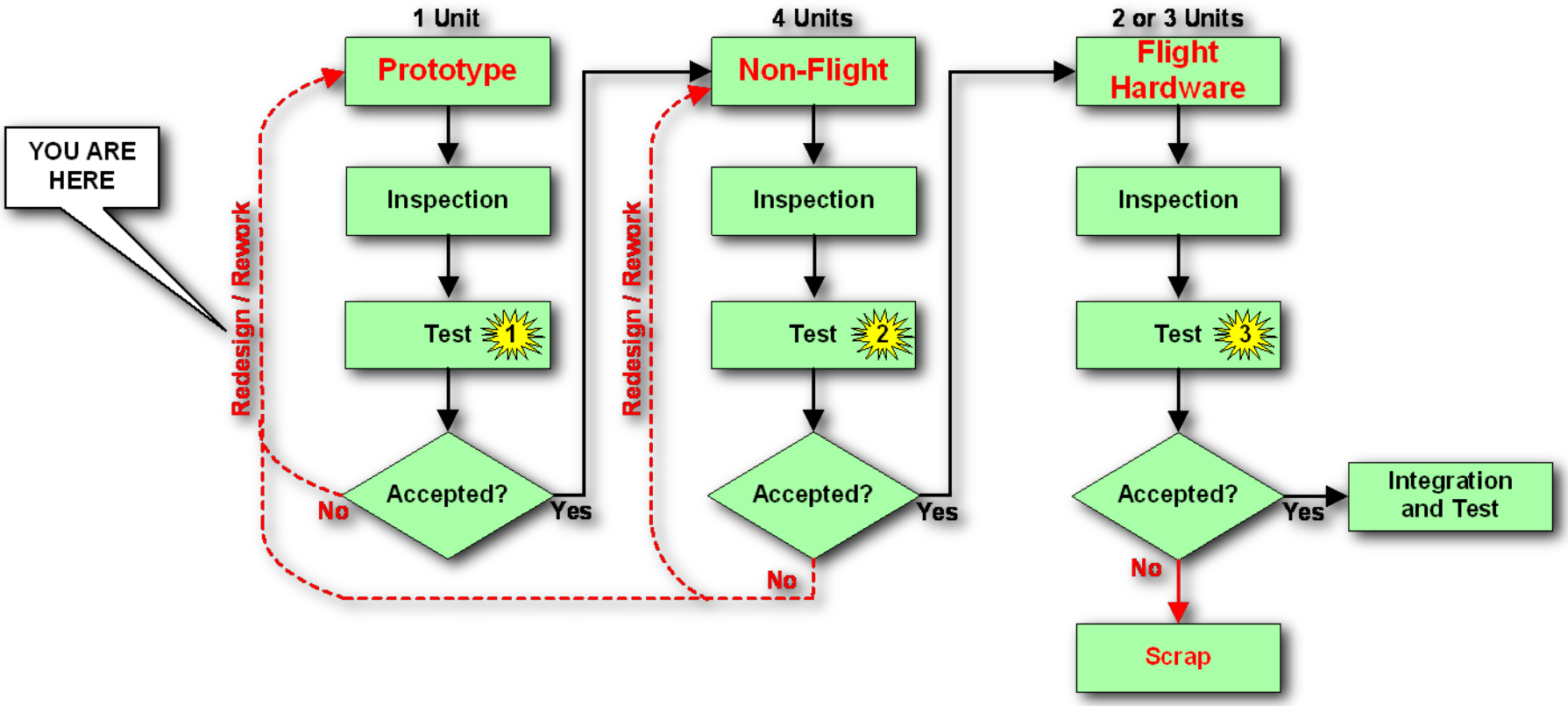
Microphonics



The Path Ahead

"How are we Going to Make Sure that the Sucker Works?"

Project Life Cycle (Tomorrow)



Questions & Answers

The End

juan-rivera@sbcglobal.net